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Dr. B. F. Davenport
Boston,

THE

DOMESTIC CHEMIST:

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1831.

WILLIAM HENRY COX,
55, Great Queen Street, Lincoln's Inn Fields.

PREFACE.

It will be manifest to all persons who deign to look into the following pages, that, if properly executed, the work is adapted to become of great public utility. The principal aim of it is to erect a barricade against the cupidity of fraudulent tradesmen, and to put it into every man's power to ensure his health and wealth against the ravages of adulteration and disease. That this is a well-timed and necessary object, will be denied by few persons of observation. Pecuniary losses, the production of ill-health, and many other evils of magnitude are the natural and diurnal consequences of the consumption of adulterated food; while lingering and tormenting disorders, and even death itself, are the more appalling results of the employment of sophisticated drugs. To guard against these effects—to enable every individual to protect his person and property from the machinations of demons in whom the

love of gain is paramount to all other considerations—this is the object of the DOMESTIC CHEMIST.

This work, therefore, is adapted to show the use of chemistry in common life. It exhibits the direct application of a refined science to the ordinary business of society. It proves that the comforts, the pleasures, even the pecuniary means of man, are capable of being increased by turning to a proper use the facts which are developed by the progress of experimental science. Chemistry is not that frivolous and fruitless pursuit which many consider it to be. But, on the contrary, while its study is eminently qualified to enlarge and fertilize the mind, there is no science so fitting to be drawn upon for special and profitable applications.

The DOMESTIC CHEMIST is divided into three parts:—

The First Part contains instructions for the detection of poisons in vegetable or animal mixtures. These instructions apply to the analysis of broth, puddings, porridge, milk, wine —to the liquids or solids removed from a sick or deceased person's stomach—and to all other

mixtures which are suspected to consist of poisons accompanied by food or physic. The poisons, herein treated of, are not only such as are commonly employed with intent to commit murder or suicide, but such also as win their way into food by the more ordinary process of accident. The experiments which are given for the detection of these poisons are simple and of easy performance. The information they afford will be found useful to physicians, coroners, jurymen, and all persons who are liable to be called upon to inquire juridically into the causes of sudden deaths.

The Second Part contains instructions for examining the purity of the drugs, aliments, and chemicals, which are of common use in domestic economy, medicine, and the arts. It is notorious that most of the articles which come from the druggist, the grocer, the publican, and the oilman, are liable to occasional adulteration; and the object of this division of the Domestic Chemist, is to describe the experiments by which the detection of such adulterations can be effected with most ease, certainty, and economy.

The Third Part comprehends numerous prac-

tical details, without which the work would be of little utility to the general reader. These details relate to the preparation of chemical tests, to the art of executing the ordinary analytical operations, and to the form, size, and structure of the instruments and vessels, which are indispensably requisite in the performance of chemical experiments. Such as are acquainted with the general principles of practical chemistry, and are provided with the convenience of a well-appointed laboratory, may possibly consider these details to be superfluous; but the man who attempts to set his first analysis in operation, without a living instructor, and with no other guide than the DOMESTIC CHEMIST, will be little disposed to complain of this excess of information.

London, November 30, 1831.

CONTENTS.

THE DOMESTIC CHEMIST.

PART I.

Instructions for the Detection of Poisons in Mixtures which contain Vegetable or Animal Substances.

On taking up this subject, I set it aside as a matter of indifference, whether the poisons which are contained in the substances to be examined, were inserted with design or by accident. For the sake of having a straight-forward case, I make the subjoined admission:—*You have a poisoned substance to examine, and the poison to be detected is one of the following:*

1. Copper.
2. Lead.
3. Antimony.
4. Arsenic.
5. Mercury.
6. Iron.
7. Barytes.
8. Lime.
9. Alumina.
10. Potash.
11. Soda.
12. Sulphuric acid.
13. Nitric acid.
14. Muriatic acid.

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15. Prussic acid.
16. Oxalic acid.
17. Opium.

COPPER.

Detection of Copper in Solutions, by means of Ammonia.—If you wish to know whether a given liquid contains copper, pour about a tea-spoonful of it into a test tube, and add to it a few drops of liquid ammonia. If copper is present, unaccompanied by vegetable or animal matter, the liquid will immediately assume a beautiful blue colour. But ammonia is incapable of producing this blue colour, when the cupreous solution contains a large proportion of vegetable or animal substances, or the colour of the liquid is dark, and the copper is present in but small proportion. When white wine contains a pretty large quantity of copper, the addition of an excess of ammonia produces merely a dirty green or brown colour, and a blue solution is produced only when the proportion of dissolved copper is very considerable; and when a solution of copper is *strongly coloured* by organic substances, then an excess of ammonia produces no blue colour, even though a pretty large quantity of copper be present. Red wine, containing copper in solution, acquires from ammonia only a dirty brown colour, a change precisely similar to that produced by ammonia in perfectly pure red wine. Thus then, the influence of organic matter on the re-actions of ammonia and copper, is very considerable, although this is a point on which the majority of English chemical books gives the reader no information. I have there-

fore paid, in this case, as I shall pay in other cases, particular attention to the effects of this influence, in order that the reader may rightly comprehend the indications of the phenomena produced by his experiments.

The test, ammonia, which I have here spoken of, and the other tests which I shall have occasion to name, will be described in the third part of this work. The liquids which are exposed to the action of the tests should be contained in small unornamented wine glasses, or in glass tubes closed at one end, about four inches in length, and one third of an inch in width.

Detection of Copper by Prussiate of Potash.—One of the most trustworthy re-agents for readily detecting copper in such solutions as contain a large quantity of non-volatile organic substances, is a solution of yellow prussiate of potash. Even when the slightest traces of copper are contained in a solution with very considerable quantities of organic substances, the solution of yellow prussiate of potash produces the same characteristic reddish-coloured precipitate, which it produces in solutions of pure copper. It is necessary, that the solution be either neutral or slightly acid, and not alcaline. Slight traces of copper can be detected in this manner in white wine, and in solutions of sugar and other organic substances. The solutions, however, must not be very strongly coloured, otherwise the test becomes ineffectual. In red wine, for example, it is impossible to detect copper by prussiate of

potash, unless indeed the copper be present in considerable quantity.

Detection by Butter.—This substance acts with great sensibility as a test for copper in mixed solutions. If a morsel of butter is put into any kind of dirty water, or solution of organic substances, such as brandy, contaminated by copper, the butter gradually acquires a *green colour*. But when the quantity of copper is very small, the test is often some days in manifesting its presence; otherwise, it would be proper to employ butter in preference to most other re-agents for copper.

Detection by Iron.—The surest way of detecting the slightest traces of copper in solution, is to precipitate it in the state of metallic copper by clean iron. You put the liquid into a glass, render it slightly acid by the addition of a little muriatic acid, or nitric acid, and then place in the mixture a clean knife blade, or any other piece of polished iron. No other precaution is necessary. After a short time, the iron becomes coated with metallic copper. Even when the solution contains organic substances of every description, and is quite darkly coloured, or even completely opaque, the presence of the slightest traces of copper are detected by the copper-red coating acquired by the iron. When the solution contains but a very small quantity of copper, the iron does not become coated with the metallic copper until it has been exposed to the solution for several hours.

Detection by Sulphuretted Hydrogen.—The

above process for the detection of copper is better than that of precipitating it by means of sulphuretted hydrogen gas. The reason is, that small quantities of the sulphuret of copper are separated from the solution by filtration with great difficulty, and are often retained a long time in suspension, in solutions which contain much organic matter. When solutions are strongly coloured, the precipitate produced by sulphuretted hydrogen is difficult to be seen; and in all cases, blank iron is a much more delicate test than sulphuretted hydrogen.

Detection of Copper in Solid Substances.—If the substance which you suspect to contain copper is *solid* or of a *pasty* consistence, the proper method of proceeding is as follows:—You cut the substance into very small pieces, or pound it to a pap, which you put into a clean Florence flask, with three or four times its bulk of water and a little nitric acid. You heat the flask over a lamp or fire for half an hour, then allow the liquor to settle, and afterwards filter it through a folded piece of white blotting paper placed in a glass funnel. The clear liquid which runs through the paper contains the copper dissolved in nitric acid. The presence of the copper can be detected by the application of ammonia or polished iron in the manner described above. It is advisable in some cases to char the solid organic matter by heating it to redness in a crucible, and then to treat the charred mass with diluted nitric acid. But extremely

slight traces of copper, when mingled with very large quantities of solid organic substances, cannot be detected by this process. There is a method, however, of detecting even the very slightest traces of copper, and by means of which the presence of copper can be detected in food which has been boiled in copper vessels, and in bread which has been adulterated by the addition of a minute proportion of blue vitriol. This method is as follows:—

Mix the substance with a quantity of water sufficient to produce a soft paste, and then mix the paste with twice its weight of pulverised crystals of carbonate of soda. Put the mixture into a small Hessian crucible (an earthen vessel which you can purchase of any ironmonger), place on the cover, and fix the crucible over the flame of a lamp, or in a charcoal fire. Let the heat be gradually raised, and finally expose the crucible to a full red heat for a quarter of an hour. When the crucible is cold, scrape out the charred mass and levigate it very fine in an agate mortar. First place a portion of the mass in the mortar, and after moistening it with water, levigate it very finely; then pour more water into the mortar, and after stirring it round with the pestle, carefully pour it off with the charcoal powder in suspension. Then pulverise the remainder of the mass in the same manner, and continue the grinding and washing until the mortar is entirely freed from charcoal. The copper should then re-

main at the bottom of the mortar in the state of minute metallic copper-coloured scales.—You must take care, in pouring off the charcoal, not to pour it off before the particles of copper have subsided. If a smaller quantity of carbonate of soda is taken than that which is here prescribed, the copper can still be reduced, but it is then so finely divided that it is liable to be washed away with the charcoal. It is necessary to allow the crucible to be thoroughly ignited, in order that the minute particles of the reduced copper may better unite together. To prevent the destruction of the crucible by the carbonate of soda in the heat, it is proper to lay at the bottom of it a portion of the substance for analysis, unmingled with carbonate of soda.

You may probably consider this last process to be unnecessarily troublesome; but I beg of you to remember, that as desperate diseases require desperate remedies, so delicate cases of poisoning or adulteration require delicate experiments to be employed in their investigation. I have given you ready methods for detecting a large proportion of copper, and I have detailed the safest and surest method of detecting the very smallest proportion. Those methods of proceeding, and that degree of care which are sufficient in ordinary cases, are inadequate to the purpose, when a minute proportion of a substance is to be detected, or when the determination of the question is to be followed by momentous proceedings.

Many unpleasant and fatal accidents have

occurred in consequence of the accidental contamination of food by copper. The following information may therefore be found useful.—It is dangerous to leave food of any kind in contact with cold copper. Pure water does not act upon copper, nor does food become poisonous from being *boiled* in *clean* copper vessels. But every kind of salt, dirty, greasy, or acid water, acts rapidly upon copper; and if food is *allowed to cool* in copper vessels, after being boiled therein, it speedily becomes poisonous. Copper pots or pans should never be employed to contain wine, vinegar, milk, butter, oil, or any species of food liable to become greasy or sour.

White of eggs is the best antidote against the poison of copper.

LEAD.

If you wish to know, whether a given liquid contains lead, add to a small portion of it, contained in a test tube, a little diluted *sulphuric acid*, or a few drops of a solution of *sulphate of soda*. If the liquid contains lead, these tests produce a white powder or precipitate. This powder scarcely dissolves at all in diluted acids, but it dissolves in a solution of caustic potash. The production of this precipitate is an excellent method of determining the presence of lead, because sulphuric acid produces precipitates which are characterised by insolubility in acids with no other substances than lead and alcaline earths, *viz.* lime, barytes, and stron-

tian; and sulphate of lead is distinguished from these earthy sulphates, by being soluble in a solution of potash, and more particularly by instantly assuming a black colour on being moistened with hydrosulphuret of ammonia.

When a solution of lead contains a very large quantity of organic substances, so as even to be very strongly coloured thereby, it still affords a precipitate with sulphuric acid. The presence of lead in the precipitate can be easily demonstrated by the following process: —allow the precipitate to settle, pour the clear liquid through a paper filter placed in a glass funnel, and bring the precipitate with the last portion of the solution upon the filter. Pour clean water in small quantities over the precipitate to wash it, then dry it on the paper, and afterwards mix a piece of it, the size of a large pin's head, with a little dry carbonate of soda. Place the mixture on a piece of charcoal, and direct upon it the flame of a lamp or candle by means of a blowpipe; thereupon, the precipitate will be reduced to globules of metallic lead, which may easily be flattened by a hammer, and will not be brittle. During the operation, the charcoal receives a coating of yellow powder, which is an oxide of lead. The blowpipe is an instrument which can be purchased for sixpence of any ironmonger, goldsmith's tool-maker, or glass-blower. It requires but little skill to raise a flame sufficient to reduce the salts of lead to the metallic state, while their reduction is the

surest of all methods of demonstrating the presence of lead.

The presence of gum in a solution containing lead, keeps the sulphate of lead produced by sulphuric acid from subsiding. The precipitate, in that case, remains a long time suspended in the solution, and is filtered with difficulty.

If a solution, which contains much organic matter, contains merely traces of lead, then no precipitate is produced by sulphuric acid. In this case, the solution must be rendered slightly acid by the addition of a small quantity of nitric acid, and then be subjected to a current of *sulphuretted hydrogen gas*. This test produces a black precipitate, which consists of sulphuret of lead. It is not till after some time that this precipitate fully subsides. The precipitate falls down sooner if the mixture is heated. When the solution to be tested is of small bulk, the lead can be sufficiently well precipitated in the state of sulphuret by merely adding to the solution an excess of *liquid sulphuretted hydrogen*. The precipitate must in this case, as well as in that described above, be fused with carbonate of soda on charcoal before the blowpipe, for the purpose of demonstrating the presence of lead. This precaution is indispensable. It is not safe to pronounce on the presence of lead in wine or other organic mixtures from the production of a precipitate, or a change of colour, on the addition of one of the above-named

tests. It is extremely difficult to observe through the deep-red colour of certain wines, the particular shade of colour which characterises the sulphuret of lead; while on the other hand, sulphuretted hydrogen produces precipitates of various colours in wines which have undergone no adulteration. I have told you that sulphuric acid produces with lead a white precipitate which becomes black on the addition of sulphuretted hydrogen; but the precipitates produced by sulphuric acid in wine, are always more or less coloured, and the change of colour produced by the addition of sulphuretted hydrogen, is not readily observed by an inexperienced eye. The reduction of the precipitates to *metallic lead* is therefore the only safe and sure method of coming to a conclusion.

The trouble of heating the precipitate before the blowpipe is very little; the operation requires less than five minutes' time, though the description of it requires more; but even if it required a longer period, it must still be done, for it is a *necessary* part of the operation. If you pretend to *analyse* things, you must make experiments which can be depended upon, otherwise your labour will be worthless. Do not believe that these precautions are useless. It is true, that they are not insisted upon in the majority of books which have been written upon this subject, but it is on that account that I insist upon them the more strenuously in this book.

When lead is mingled with solid or pasty,

vegetable or animal matters, it is best to follow a proceeding similar to that recommended for the detection of copper in such substances (page 6). Mix the whole mass with carbonate of soda, and expose it to a red heat in a covered Hessian crucible. You must take care not to employ too powerful a heat in this operation, lest the reduced lead should be volatilized. After becoming cool, the fused mass is pulverized in an agate mortar with water, and the charcoal carefully washed away. The reduced metallic lead then remains behind in the mortar, and can be easily recognised. The method of washing the mass in the water is the same as that described at page 6.

The following method of detecting lead in wine, is one which always succeeds, and which leaves no uncertainty in the mind as to the nature of the metal which is indicated to be present. Evaporate a portion of the wine to dryness. To do this, boil it in a saucer or capsule of china, or Wedgewood's ware, over a lamp, until all the liquid has flown away. Scrape the dry residue together, and make it red-hot in a small crucible or a tobacco-pipe, by which means it will be reduced to charcoal. Triturate the charcoal with twice its weight of nitrate of potash, and decompose the mixture by throwing it, a little at a time, into a small porcelain crucible, kept red-hot over a lamp or charcoal fire. The mixture of charcoal and nitrate of potash deflagrates or makes a gentle explosion with production of fire,

and a fused mass remains in the crucible. If the matter retains a deep brown colour, you must add a little more nitrate of potash and ignite it again. When this operation is over, you must pour into the crucible, a little at a time, a mixture of water with a small proportion of nitric acid. This mixture will completely dissolve the fused mass in the crucible. The resulting solution must be filtered through a paper filter, contained in a glass funnel, and the presence of lead must be sought for in the filtered liquor, which will be transparent and nearly colourless. Put a few drops of this liquor into several small test-glasses, and add to each a few drops of the following tests:—a solution of *sulphate of soda* will produce a white precipitate; a solution of *carbonate of soda,* the same; *ammonia,* the same; a solution of *chromate of potash* produces a yellow precipitate; *liquid sulphuretted hydrogen* and *hydrosulphuret of ammonia* produce black precipitates.

Litharge, red lead, and white lead, are extensively employed in house painting. Sugar of lead is much employed in surgery as well as in many arts: it is with the latter that goulard water is prepared. All these compounds are highly poisonous.

Water often contains lead, gained from the roofs of houses, water pipes, or cisterns. Pure water dissolves lead more easily than water which contains gypsum, or other neutral

salts; but water, containing decayed leaves and other vegetable matter, possesses a considerable solvent power on lead. Milk has often been rendered poisonous by being kept in leaden troughs. Acids of all kinds dissolve lead and its compounds. Wine and distilled spirits are capable of dissolving lead. Cider is frequently rendered poisonous by lead, generally in consequence of the addition of sugar of lead as a corrective of acescency, and sometimes because lead is permitted to form part of the apparatus employed in the manufacture of cider. The lead glazing of earthenware is capable of being dissolved by vinegar and other acids as well as by fat substances, and many articles of food have been rendered poisonous in this manner. Sour wine is frequently improved in taste by the addition of litharge. Many kinds of spirituous liquors and preserves are frequently adulterated by the addition of sugar of lead for the purpose of clarifying them or depriving them of colour.

ANTIMONY.

Tartar emetic, a compound which contains antimony, is well known as a powerful emetic. A case occurred lately, in which a quantity of this substance was given in food to the men composing a jury, whether in joke, or with a view to poison them, is not yet known.

If the organic matter, suspected to contain tartar emetic, is in a liquid state, you must render the solution acid by adding muriatic acid, and then pass into it a current of sulphu-

retted hydrogen gas, which will produce an orange-red precipitate. If you allow the solution to be neutral or alcaline, the sulphuretted hydrogen produces merely a red colour without a precipitate; but the latter can be made to appear either by adding muriatic acid or applying heat to the solution.

If the substance to be examined is pasty or solid, it must be boiled in water, containing a mixture of muriatic and tartaric acids. The solution thus prepared is to be filtered through a paper filter, and the clear liquor is to be tested with sulphuretted hydrogen gas in the manner described above. The presence of tea, porter, broth, or milk, does not hinder the production of the peculiar orange-red precipitate which indicates so characteristically the presence of antimony.

The precipitate can be separated from the solution by passing the latter through a paper filter. The precipitate should be dried, and if the inquiry is an important one, the antimony and sulphur, which are the component parts of the precipitate, should be separated from each other so as to leave the antimony in a free state. You effect this, by putting the precipitate into a glass bulb, blown in the middle of a glass tube, and passing through the tube a slow current of hydrogen gas, prepared in the usual manner from iron and diluted sulphuric acid. During the passing of the hydrogen gas over the sulphuret of antimony, it is necessary to apply the flame of a small spirit lamp to the bulb in the glass tube, by which

means the decomposition of the sulphuret is facilitated. Sulphuretted hydrogen gas passes from the open extremity of the glass tube and metallic antimony remains in the bulb. When the current of gas is too rapid, the metallic antimony sublimes in the form of minute scaly crystals.

Antimony and its compounds, when heated before the blowpipe, produce a greenish blue flame.

ARSENIC.

This is the substance most generally employed for the purpose of poisoning. It is easy to be procured, readily administered, and certain in its effects. Its properties are universally known to the vulgar, and are held in so high esteem by the wicked and the weak, that seldom a month passes, without our hearing of a case, either of murder or suicide. The frequent production of sudden death by arsenic, leads people to infer that arsenic has been resorted to in many cases of sudden death, which have nevertheless been brought about by other causes. The assistance of medical men being called in upon such occasions, it behoves them to be well acquainted with the methods of detecting this baneful mineral. But although there are few substances which are so easy of detection as arsenic, yet the generality of medical practitioners display a most reprehensible degree of ignorance of the subject, and scarcely one in fifty of them is capable of determining with accuracy, whe-

ther a pudding or a mess of pottage be contaminated with arsenic or not. Even the whole medical staff of our great metropolitan hospitals are often incapable of clubbing together a sufficient degree of chemical knowledge to perform the common operations of an analysis. I think myself tolerably well borne out in this assertion by the facts which are detailed in the following quotation:—

"*Attempt to Poison.*—On the evening of Thursday week, Mr. and Mrs. Dowling, their daughter, and a friend, discovered, while taking their tea, that it had a very unusual taste, and on referring to the tea-pot, they found the water impregnated with a white powder, part of which floated on the surface. The tea-kettle was also found to contain a quantity of the same ingredient. Mr. Dowling desired them all to drink a quantity of warm water, and went himself for the nearest medical man (Mr. Stringer), who administered strong emetics. Mr. Stringer was of opinion at first, that the ingredient was arsenic, but with a view of obtaining the more satisfactory evidence, he sent the kettle and its contents to Guy's Hospital, with the request that it might be analysed. The answer to his request was that they *were then busy*, but would do it in the course of the day; but on a messenger calling on the following day, the kettle was *returned to him*, and he was told that the gentleman, whose department it was to attend to these matters, was out of town. Subsequently, Mr. Stringer analysed the contents of the kettle, and they proved to be arsenic. Mr. Dowling lives in a house, a certain portion of which is occupied by a number of single men of the police. Mr. Dowling has not at present the least clue to the perpetrator of this diabolical act, at which every one must shudder, and particularly when it is known, as it is stated by the men generally under Mr. Dowling's superintendence, that his kind treatment of them is quite proverbial throughout the force."—*From* "*The Ballot*" *of August* 7, 1831.

Is it creditable to an establishment like Guy's Hospital, that the medical staff should be so ignorant of chemistry as to be unable to tell whether a white powder, floating in a tea-kettle of hot water, *was* or *was not* arsenic? Is it proper that they should keep a family in a state of fearful anxiety for four-and-twenty hours, and then refuse to answer such a question? Is it not the duty of a public medical establishment to attend promptly to cases of this sort? If not, why have we no medical police? Such negligence dooms the sick to death, and permits the murderer to escape. Was the chemist of Guy really *"not at home," i. e.* was he afraid of committing himself? There verily appears to be something rotten in the state of science in this quarter of the world.

The substance called *arsenic* by chemists is a metal, but that which is called *arsenic* by the vulgar is a compound of this metal with oxygen. This compound is known under the additional names of *white arsenic, oxide of arsenic,* and *arsenious acid.* There are several other compounds of arsenic employed in the arts, namely, the sulphurets of arsenic (which comprise realgar, orpiment, and king's yellow), the arsenite of copper, the arsenite of potash, and the arseniate of potash. But of all these poisonous substances, white arsenic is that which is of most importance; because the others are not well adapted to the use of the murderer.

Detection of White Arsenic.—White arsenic

is sold in the shops in two states. First, as a white powder pounded as fine as flour; secondly, in white solid lumps which break with a shelly fracture and sharp edges, which are sometimes opaque and sometimes semi-transparent. It is nearly four times as heavy as water. It has little or no taste, or is faintly sweetish; it is dangerous to taste it. Thirty-three parts of water boiled with a quantity of arsenic, retain only *one* part in solution after becoming cool. This liquor is a strong poison. Water which contains organic matter in solution, dissolves a still smaller quantity of arsenic, and some animal mixtures will dissolve none.

White arsenic may be presented for analysis in three different states. 1. As a dry powder. 2. Dissolved in water, but free from animal or vegetable matter. 3. Mingled with animal or vegetable solids or liquids.—If Mr. Stringer had filtered the contents of the tea-kettle spoken of above, he would have had a simple solution of arsenic in water *(second state)*, and a portion of solid arsenic *(first state)*. If he had taken for analysis a cup of the tea prepared with the poisoned water, he would have had arsenic in the *third state*, namely, in solution with vegetable matter (tea, sugar) and animal matter (milk). According as arsenic is presented in one or other of these three states, it is necessary to vary the process adopted to detect it. Care should be taken, when a mixture, containing arsenic, is presented for examination, to pick out, if

possible, a few solid grains of the poison. Such grains are frequently found adhering to the inner coat of the stomach when examined after death, and they may often be separated from pudding and porridge by stirring the mass in water, whereupon the arsenic falls in white insoluble grains to the bottom of the vessel.

To tell whether a Dry White Powder contains Arsenic.—Take a small glass tube, one-eighth of an inch in diameter, draw out one end of it so as to produce a narrow tube an inch long and one-twelfth of an inch in diameter, and terminate the narrow tube by a small bulb. This will produce an instrument resembling the following figure:—

This should be formed of green glass which has no lead in its composition. The powder, suspected to contain arsenic, is to be inserted into the bulb without soiling the sides of the tube. You may put it in by means of a narrow roll or a gutter formed of thin paper, or by a small glass funnel with a long and very narrow neck. The powder may be pushed through the funnel by a wire or a rod of glass. When the powder is inserted, take a narrow splinter of charcoal, make it red-hot by means of the blowpipe, and then insert it into the tube so as to touch the powder and project above it into the narrow part of the

tube. Take particular care not to soil the sides of the tube in inserting the piece of charcoal. Next heat that part of the tube where the charcoal lies, by holding the tube in an inclined direction across the flame of a small spirit lamp. When the charcoal is thoroughly red-hot, bring the end of the tube where the arsenic lies into the flame. The heat will immediately volatilise the arsenic, the ignited charcoal will reduce it, and absorbing its oxygen, will cause the metallic arsenic to fly upwards in vapour. But as soon as the metallic arsenic gets beyond the charcoal and the heat, it deposits itself on the sides of the glass tube. When the quantity of arsenic is very small, the tube appears black at a little distance from the place where the heat has worked. In this case you pass the tube carefully and slowly into the flame, by which means the sublimate is driven together into a narrow ring, which possesses a strong metallic brilliancy. You now cut off the tube at both sides of the ring of metal, lay hold of the piece of glass with a pair of pincers, heat it gently in the flame of the lamp, and hold your nose at the same instant over the lamp and heated glass. You then perceive the odour of garlic which characterises the vapour of metallic arsenic, and you thus avoid confounding arsenic with mercury or cadmium, both of which give shining sublimates, but do not produce the odour of garlic on being volatilised. There are few substances which give so decisive a result with a minute proportion as arsenic

tried by the above process. Every grain of white arsenic is sufficiently large for this experiment, if it can be conveyed from the place where it lies to the bottom of the glass tube in which it is to be heated. The smaller the quantity of arsenic to be tried, the narrower must the glass tube be made. The two-hundredth (probably even the three-hundredth) part of a grain of arsenic is a sufficient quantity to give a trustworthy result. The surface of a crust of metallic arsenic appears extremely brilliant in polish, and of a dark steel colour; internally it appears grayish, brilliant, and crystalline. If the extreme end of the subliming tube is broken off, and the film of arsenic is driven about the tube by repeated sublimations effected by a very small flame, it finally becomes oxidised, and forms minute octahedral crystals, the shining triangular faces of which are readily discernible with the aid of a microscope.

The following easy experiment may be employed in confirmation of the above process. Fix a minute portion of the powder to be tried on the end of a moistened glass rod, and hold the rod over boiling water till as much steam is condensed upon it as is sufficient to form a drop of water. Deposit the drop of water, which will have become a solution of arsenic, upon a slip of paper, and gently warm the paper to concentrate the solution. Then hold the paper over the mouth of a vessel from which sulphuretted hydrogen gas is being dis-

engaged. By this means, the stain produced by the solution is rendered yellow. If it is then exposed to the vapour of ammonia, it becomes colourless, but again appears yellow when the ammonia has evaporated.

To tell whether Arsenic is present in a Solution which is known to contain no Organic Matters.—A solution, free from organic substances, is obtained by dissolving the solid grains of white arsenic in water or in an alcali. Divide the solution into two portions, which are to be exposed to two different modes of treatment.

(*a*) Make the solution acid by the addition of a little muriatic acid: pass into it a current of sulphuretted hydrogen gas. If white arsenic is present, a deep yellow precipitate of sulphuret of arsenic will be produced. If no precipitate is produced, nor any yellow colour induced, the liquor certainly contains no arsenic; but the production of a yellow precipitate does not prove the presence of arsenic, because other substances give a yellow precipitate in the same circumstances. You must therefore analyse the precipitated sulphuret, and endeavour to separate the arsenic from it.

Warm the solution, allow the precipitate to settle, and then filter it through a filter formed of a piece of paper, not much more than an inch square. Wash the precipitate with the help of a washing bottle, down to the bottom of the filter, dry the filter between blotting paper, scrape off the sulphuret while in a

moist state, and dry it on a slip of glass by applying a gentle heat.

When the sulphuret is so small in quantity, that it cannot be mechanically removed from the filter, you must place the filter in a very small funnel over a clean glass, and pour liquid ammonia upon it. This will dissolve the sulphuret of arsenic, and carry it through into the glass below. Upon evaporating the ammoniacal solution, the sulphuret remains behind.

Put the dry sulphuret into a tube, such as that described at page 20, and cover it with a layer, rising one-fourth of an inch in the tube, of strongly calcined tartrate of lime, prepared just previous to its insertion into the tube by igniting the tartrate of lime, wrapped up in a piece of platinum foil, before the blowpipe. Take care to insert these substances into the tube without soiling its sides, by employing the precautions described at page 20. The tube being prepared, you first ignite the tartrate of lime by holding the tube in the flame of a spirit lamp, and then volatilise the sulphuret by suddenly applying the heat to the extremity of the tube. If arsenic is present, a crust of that metal will be formed on the tube immediately above the tartrate of lime. The entire operation and its results are similar to the reduction of oxide of arsenic by means of charcoal, which I have described above. The calcined tartrate of lime is a mixture of charcoal and quick lime: when the vapour of

sulphuret of arsenic passes through this mixture, such combinations take place as produce carbonic oxide gas, sulphuret of calcium, and metallic arsenic. The latter then deposits itself in the cool part of the tube.

(*b*) The other portion of the solution is to be subjected to the action of liquid tests. You put small quantities into little test tubes, about three inches long and half an inch wide, and add the re-agents separately to each. On the supposition that the suspected liquid really contains arsenic, it behaves with the re-agents as follows:—*Liquid sulphuretted hydrogen,* or sulphuretted hydrogen gas, added to a solution previously acidulated by muriatic acid, produces a yellow precipitate, which dissolves in any alcali. A solution of *nitrate of silver* added at the same time with liquid *ammonia,* produces a lemon-yellow precipitate. A solution of *sulphate of copper* added at the same time with liquid *ammonia,* produces a precipitate of an apple-green colour. If a liquid, suspected to contain arsenic, acts in the above manner with one of the tests but not with the others, the liquid contains no arsenic; but if it produces the three coloured precipitates with the three tests as above described, the proof of the presence of arsenic is decisive. Particular care must be taken to make the liquor *acid* for the first test, and *ammoniacal* for the two last.

To tell whether Arsenic is present in a Solution which contains Vegetable or Animal Substances.—(*a*) First remove the animal

matter as completely as possible. To do this, you add acetic acid to the solution; then stir it well, allow it to settle, and separate the precipitate by filtration. Next, render a small portion of the solution alcaline by ammonia, and add a solution of nitrate of silver: if this produces a lemon-yellow precipitate, the solution is pretty free from animal matter: if not, render the whole solution feebly alcaline, then acidulate it by muriatic acid, and add a solution of nitrate of silver. This will precipitate the remaining animal matter. Allow the liquid to settle, add a solution of common salt to precipitate the excess of nitrate of silver, and then filter the solution through paper. The resulting solution will be nearly colourless.

(*b*) Acidulate the clear solution with muriatic acid, precipitate the arsenic by a current of sulphuretted hydrogen gas, collect the yellow precipitate of sulphuret of arsenic, and reduce it to metallic arsenic by the process described in the preceding subsection, letter *a* (p. 23.) The liquid should be boiled after the addition of the sulphuretted hydrogen gas, and the precipitate should be allowed five or six hours to subside. When the precipitate has subsided, the supernatant liquid should be poured off, and be replaced by a quantity of distilled water. This makes the filtering and washing of the precipitate more easy to be effected.

To tell whether Arsenic is present in Solid Organic Substances, such as Pudding, the Contents of the Stomach, or even the Tissues of

the Stomach.—The solid matter, whatever may be its nature, is cut into very small pieces, and boiled for an hour in a large quantity of distilled water. Doctors differ as to the propriety of attempting to assist the solvent action of water by the addition of re-agents. Christison declares that nothing is necessary, Pfaff recommends the use of nitric acid, and Berzelius advises us to boil the contents of the stomach first with caustic potash and then with muriatic acid. It is probable that one or the other of these re-agents may be useful according to the nature of the substances with which the arsenic may be mixed. After the boiling is finished, you pass the solution through gauze to separate the grosser particles. Then boil the solution with caustic potash, concentrate it by evaporation, and filter it through paper. It often happens that a solution requires nearly two days to filter through paper, particularly when it has been prepared by boiling the substance of the stomach. The digesting of the solution with caustic potash, as last mentioned, serves to accelerate the filtration through paper.

When you have thus obtained a solution, you are to proceed with the examination of it in the manner described in the preceding subsection (page 25.)

MERCURY.

Next to arsenic, *corrosive sublimate,* or the perchloride of mercury, is the most virulent of the metallic poisons. It is also the poison

which, next to arsenic, is most frequently employed with a view to produce death. It is of importance, therefore, to be acquainted with its characters.

Corrosive sublimate may be presented for examination in three different states. 1. As a dry powder. 2. Dissolved in water but free from organic substances. 3. Mingled with vegetable or animal matters, either solid or in solution.—All the following experiments tend only to the detection of the *mercury* which is contained in corrosive sublimate. General instructions for the detection of *chlorine* (its other constituent), will be found in the article on Muriatic Acid.

To tell whether a given Dry Powder contains Corrosive Sublimate.—Mix it with dry carbonate of soda, put the mixture into a little glass tube and expose it to the heat of the blowpipe. If corrosive sublimate is present, it is immediately reduced, and metallic mercury sublimes in the form of a gray powder, which, on being rubbed together by a glass rod or a piece of paper, can easily be seen to form globules of metallic mercury.

Mix the dry powder with a little liquid ammonia. If it remains white, it is corrosive sublimate. If it becomes black, it is calomel. Mix it with a small quantity of a solution of caustic potash. If it becomes yellow, it is corrosive sublimate. If it turns black, it is calomel.

To tell whether a Solution, known to be free from Vegetable or Animal Substances, contains

Corrosive Sublimate.—Divide the solution into two portions.

(*a*) Acidulate one portion of the solution by muriatic acid, and mix it with a solution of protochloride of tin previously rendered clear by the addition of muriatic acid. The mixture must be allowed to boil a few minutes in a small flask. After which, you cork the flask, and allow the solution to cool and settle. If mercury is present, a black precipitate or a collection of minute metallic globules will be perceived. Decant the clear solution, add concentrated muriatic acid to the precipitate, and expose the whole to heat. This will occasion the production of large globules of metallic mercury. When the precipitate is very small in bulk, transfer it, after the solution is poured off, into a very small glass tube with a narrow point; wash it there by shaking it with water, and drawing off the solution by means of a pipette. Then cut off the bottom of the tube and dry it by a very gentle heat. If the powder does not now run into globules of mercury, pound the glass and the powder, put the whole into a capillary tube like that described at page 20, and sublime the mercury by the application of a gentle heat.

(*b*) Apply the following tests to separate quantities of the suspected solution. The effects stated to be occasioned by the tests are those which distinguish corrosive sublimate from calomel. Pass a current of sulphuretted hydrogen gas into the solution of mercury; a black precipitate is produced, which imme-

diately becomes white if you shake the mixture; continue to pass in the gas, and the precipitate will finally become completely black. Solutions of calomel give, under such a mode of treatment, a precipitate which is black from first to last. A solution of iodide of potassium produces a cinnabar red precipitate, which dissolves in an excess, either of the iodide of potassium or the corrosive sublimate. Solutions of calomel give a greenish yellow or a blackish precipitate with this test. Liquid ammonia produces a white precipitate (with calomel, a black precipitate). A solution of caustic potash produces a yellow precipitate (with calomel, a black precipitate).

These experiments are quite sufficient to distinguish mercury from other metals, and corrosive sublimate from calomel.

To tell whether Corrosive Sublimate is present in a Solution which is known to contain Vegetable or Animal Substances.—The behaviour of solutions of corrosive sublimate towards chemical tests is very considerably modified by the presence of such organic substances as cannot be volatilised without decomposition. This is the case even when the solutions are not coloured by the organic matter. The reason of this modification is, that corrosive sublimate is capable of combining with a great number of organic substances, and of forming compounds which are susceptible of decomposition, only by being acted upon in a peculiar manner. If, for example, a solution of corrosive sublimate be mixed with sugar or

with non-volatile organic acids, then, upon being tested with an excess of a solution of caustic potash, it gives no precipitate if only a small quantity of corrosive sublimate is present, on a dirty yellow precipitate if a large quantity of corrosive sublimate is present. But in both cases, after some delay, the solution deposits a heavy black precipitate which contains a very large proportion of metallic mercury. If you boil the solution after adding the test, this black precipitate is produced immediately. The same phenomena are produced by employing a solution of carbonate of potash or carbonate of soda, instead of caustic potash. Without the addition of an alcali, the reduction to metallic mercury does not take place. If you add ammonia to such a solution of corrosive sublimate, it produces a white precipitate which is capable of preserving its colour for a long time, and upon being boiled, merely becomes black in part.

When solutions of corrosive sublimate are strongly coloured by organic substances—when, for example, they contain red wine—the precipitates which they produce with a solution of potash, are dark in colour and of various hues. These precipitates become black when the solution is allowed to repose, and more rapidly so when the solution is boiled. They all contain metallic mercury. White wine, containing a large quantity of corrosive sublimate, acquires from a solution of potash a brownish red colour, but affords no immediate precipitate. But after some delay,

this solution produces a precipitate which at first is dirty brownish red and finally gray. The production of this precipitate is hastened by boiling the solution.

If you add an excess of hydrosulphuret of ammonia, or of liquid sulphuretted hydrogen to solutions of mercury, which contain much organic matter, you obtain a precipitate of sulphuret of mercury; but when the solutions possess a dark colour, this precipitate is commonly difficult to be seen. That you may determine with certainty whether the precipitated sulphuret contains mercury, you must filter the solution, dry the precipitate, and then attempt its reduction by the process described at page 28. If mercury is present, it is reduced and sublimed, precisely the same as if the pure chloride had been operated upon. But the presence of certain organic substances has the disadvantagous effect of holding the sulphuret of mercury a very long time suspended in the solution, and very frequently of partly or totally preventing its filtration. On this account, you ought only to employ sulphuretted hydrogen as the precipitant, when the quantity of mercury is very considerable. To detect a small quantity of mercury in a solution of organic matters, it is best to precipitate it by means of blank copper-plate.

In such a case, you render the mercurial solution neutral or slightly acid, and then place in it, the slip or rod of clean copper. The solution ought not to be alcaline, although mercury can be precipitated by copper, even

from an alcaline solution. By the addition of metallic copper to an acid solution, the mercury is effectually precipitated, though the solution be very deeply coloured, and contain organic matter of every description. A solution, which contains the slightest traces of mercury, is not long in communicating a gray coating to the copper put into it under the above circumstances. The gray coating, on being rubbed with paper, gives a silvery appearance to the copper, but one which a gentle heat is sufficient to drive away. When the quantity of the dissolved mercury is exceedingly small, the silvery appearance produced upon the copper is less distinct, because the characteristic colour of the copper shines through the thin coating of mercury. In this case, you must heat the copper in several spots by means of the blowpipe flame, and thus restore its own pure colour. The slight silvery appearance on the places which you do not heat, is then rendered more striking by contrast.

To tell whether Corrosive Sublimate is present in Solid Organic Substances.—Cut the solid substances into very small fragments and boil the mass in distilled water; filter the solution thus produced and submit the filtered liquor to the operations described in the preceding subsection. If these operations demonstrate the presence of mercury the inquiry is finished; if they do not, the inquiry is to be pursued. It may happen that the compounds produced by the combination of the corrosive

sublimate with the organic matters may not be capable of solution in distilled water; in which case, they will remain with the undissolved substances separated from the solution by the filter.

When corrosive sublimate is contained in pasty or solid organic substances which are not soluble in water, they are, if possible, to be dissolved in liquid ammonia. The precipitate which is produced by albumen in solutions of corrosive sublimate, is insoluble in water, but easily soluble in ammonia, or in a solution of potash. It is possible to precipitate the mercury from the ammoniacal solution by hydrosulphuret of ammonia; but the sulphuret of mercury remains a very long time suspended in the solution and can scarcely be separated from it. Yet its separation is absolutely necessary, because it must be examined for mercury before the blowpipe, (p. 32.) It is therefore much better to place a blank copper-plate in the ammoniacal solution, from which, as well as from a neutral or a slightly acid solution, the mercury can be precipitated by this metal. The copper acquires a gray surface, which, on being rubbed by paper, becomes bright and silvery. Even slight traces of mercury can be thus detected in the ammoniacal solution. It is probable that the presence of mercury in blood, should this fluid contain that metal, could be best detected by this process, since the whole of the constituents of blood are soluble in an excess of ammonia.

It is improper to employ a solution of potash instead of liquid ammonia, as a solvent for organic solids. The presence of mercury cannot be detected in a solution of potash by hydrosulphuret of ammonia, for the resulting sulphuret of mercury remains in solution, provided a sufficient quantity of the potash be present. The mercury can, indeed, be precipitated from such a solution by blank copper-plate, but the precipitation is not so complete as when effected in an ammoniacal solution.

When the mercurial organic substance is soluble neither in water nor in ammonia, it is customary to digest it with diluted nitric acid, and to seek for the mercury in the resulting acid solution. But this method of analysis is frequently disadvantagous, particularly when the quantity of the organic substance is considerable, and that of the mercury very small. It is better in such cases to adopt the process which follows:—

Separation of Mercury from Organic Substances by Distillation.—The dry substance is mingled with about three times or four times its weight of carbonate of soda, or carbonate of potash, and the mixture is placed in a retort which should be large enough to contain four times as much as the bulk of the mixture. Water is then added in sufficient quantity to make the whole mixture into a paste, and the retort is shaken until the dry substance is properly mingled with the water. If the body for examination is of a pasty consistence, it must be mingled with carbonate of soda, and

then dried at a very gentle heat, to bring it into a fit state to be inserted into the retort. The neck of the retort is connected, by means of a cork, with a receiver, but the juncture must not be quite air-tight. The retort is then gradually heated, and the heat is increased, till the bottom of the retort becomes red-hot. When the quantity of the substance for examination is inconsiderable, so that the operation can be performed in a small retort, the heat can be best applied by the flame of a large spirit lamp; but when the quantity is large, it is, of course, necessary to employ a charcoal fire. The mass in the retort commonly swells up very much, and you must take great care not to allow it to rise into the neck. After the cooling of the apparatus, you break off the neck of the retort, close to the body, and then split the neck longitudinally, effecting the fracture with the help of a hot coal. The interior of the neck is found to be covered with a glutinous brown empyreumatic oil, and at about an inch from the body of the retort, a quantity of minute globules of mercury are observable. The existence of these mercurial globules is demonstrated with most certainty, by rubbing your finger on the place where they appear to be fixed, and then examining the substance which is transferred to your finger. The globules of mercury can readily be recognised upon the finger, even by the unassisted eye, but still better when a lens is employed. It is necessary to remove the globules from the glass, prior to examina-

tion, lest the eye be deceived; for when small air bubbles become fixed in the glutinous oil on the glass, they can easily be mistaken for globules of mercury. When the organic substance thus operated upon, contains but a small quantity of mercury, the whole of the metal remains in the neck of the retort, and none passes with the empyreumatic oil into the receiver. When no globules of mercury have been produced by this experiment, you may digest the oil which is in the receiver, together with that which remains in the broken neck of the retort, in nitric acid, and test the resulting acid solution for mercury. But when the foregoing operation has been performed with a proper degree of care, and no mercury is found in the neck of the retort, it is seldom that its presence can be detected in the nitric acid solution.

IRON.

This substance, though not strictly a poison, is liable to produce very injurious, if not fatal consequences, when taken into the human body in considerable quantities. But if iron is not much to be dreaded as a poison, it requires to be daily watched for as an adulterant. Green vitriol or sulphate of iron, a substance of great importance in the arts, is one of the compounds most commonly resorted to in the adulteration of beer.

It is a common practice with the publicans of London to mix all kinds of strong beer with a considerable proportion of small beer or

water, and as this produces a mixture so *flat* to the taste as to be liable to detection, they give an artificial *roughness* to the diluted beer, by adding to it a solution of green vitriol. It is true, that the latter is never added to the beer in such a proportion as to render the beverage poisonous; but since the presence of iron in beer serves to prove the fact of dilution, it is highly important to the public to be put into possession of a method of readily detecting that adulterant.

Iron is capable of existing in solution in two different states, firstly, in the state of *protoxide of iron*, and secondly, in the state of *peroxide of iron*. When green vitriol is prepared by dissolving iron in sulphuric acid in close vessels, the resulting solution contains *protoxide* of iron; but when this solution has been exposed to the atmosphere, or has been boiled, or mixed with strong acids, the solution contains *peroxide* of iron. Now this difference is a matter of great importance to the analyst, because the tests which act in a certain manner with solutions containing protoxide of iron, act in a totally different manner with solutions containing peroxide of iron. Yet this difference has not been attended to by many persons who have written about the detection of iron, and the necessary consequence is, that their instructions are vague, contradictory, and unsatisfactory.

A solution containing protoxide of iron dissolved in an acid, but without organic matter, behaves towards re-agents as follows:—A

solution of yellow prussiate of potash, gives a white precipitate, which soon becomes light blue, and afterwards dark blue. Air and heat hasten the production of the blue colour. A solution of red prussiate of potash produces an immediate dark blue precipitate. Hydrosulphuret of ammonia produces in neutral solutions a black precipitate, which turns reddish brown when exposed to the air. Liquid sulphuretted hydrogen produces no precipitate. A solution of potash produces a white precipitate which gradually becomes gray, green, and brown. The presence of a large quantity of organic substances hinders the precipitation of protoxide of iron by potash and other alcalies.

A solution containing *peroxide* of iron, instead of protoxide, behaves as follows:—A solution of yellow prussiate of potash gives an immediate dark blue precipitate. A solution of red prussiate of potash gives no precipitate, but deepens the colour of the solution of iron. Hydrosulphuret of ammonia behaves the same as with solutions of protoxide. Liquid sulphuretted hydrogen gives a milky white precipitate which consists of sulphur, and the peroxide of iron is reduced to protoxide, which rests in solution. A solution of potash produces a reddish brown bulky precipitate. All non-volatile organic matters hinder the precipitation of peroxide of iron by potash and other alcalies, but they do not hinder the production of precipitates by prussiate of potash and hydrosulphuret of ammonia.

When a solution containing protoxide of iron is exposed to the air, oxygen is rapidly absorbed, and the protoxide is gradually converted into peroxide. Hence a solution of protoxide of iron, when tested with re-agents in the ordinary manner, behaves in general like a mixture of protoxide and peroxide. It is impossible to comprehend the indications of many re-agents, without keeping in view the circumstances just alluded to. Thus it is broadly stated in chemical books, that prussiate of potash gives a blue precipitate with solutions which contain iron. This is true only to a certain extent, for a solution of pure protoxide of iron gives a perfectly white precipitate with the yellow prussiate of potash. But when a person knows the different relations of the two prussiates towards solutions of the two oxides, he is not liable to be deceived by such a phenomenon as that just described. It is of importance to bear in mind, that as the yellow prussiate of potash gives a blue precipitate with solutions of the peroxide, and the red prussiate of potash the same precipitate with solutions of the protoxide, it follows that a mixture of the two prussiates must give a blue precipitate with either of the two oxides, or a mixture of the two oxides the same precipitate with either of the two prussiates. Therefore, if you mix a solution of the yellow prussiate of potash with a solution of the red prussiate, you form a compound test capable of producing a blue precipitate with any solution which contains

iron, without the least regard to the state of oxidation of the iron.

The green vitriol employed by publicans to adulterate beer, contains the *protoxide* of iron; but the unavoidable exposure of the salt to atmospheric air, both *previous* and *subsequent* to its admixture with the beer, has so powerful an effect on its composition, that the beer when brought home from the publicans in the usual pots, is invariably found to contain both protoxide and peroxide of iron. Hence the best test which can be applied is the mixed solution of prussiates which has been mentioned in the preceding paragraph. When you add a drop or two of this test to a few drops of the adulterated beer, you obtain an immediate precipitate. It matters not whether the iron be wholly in the state of peroxide or of protoxide: it cannot escape the re-action of this compound test. It is quite unnecessary to subject the beer to evaporation, or any other preparation. The test is so delicate that it produces a precipitate in solutions containing iron in extremely small quantity. The precipitate forms large clouds which rise to the surface of the beer, and do not sink to the bottom in the usual manner of precipitates. And it requires to be noticed, by the way, that the blue precipitate always appears *more or less green*, according to the quantity and intensity of the brown colouring matter of the beer. A spoonful of beer and a single drop of the test

are sufficient to decide any question respecting the presence or absence of iron. Dr. Forsyth's process for detecting iron in beer, which begins with "Boil down gently a GALLON of the suspected beer to a pint"—(*New Test Book*, p. 19), though a very elegant process for such as are fond of microscopic experiments, and though it be admirable for convenience and economy, is one which I cannot take upon me to recommend, never having *practically* discovered in what its advantages lie.

There are cases of analysis in which it is necessary to precipitate the whole of the iron which may be contained in a particular solution, and I shall here describe *one* of many methods of doing so. You begin by boiling the solution with a very small quantity of nitric acid. This converts all the iron into peroxide. You then gradually add a slight excess of liquid ammonia to the solution. This precipitates the peroxide in the state of a reddish brown powder, which can be separated from the solution by filtration.

When iron is to be detected in solid organic substances, a solution may be obtained by boiling the solid substances in water acidulated by sulphuric or muriatic acid (not by nitric acid). Or the organic substances may first be charred in a tobacco-pipe or a crucible, and the charred residue be treated with the diluted acid. When a solution is prepared and filtered, it may be exposed to the action

of the various re-agents which have been cited above.

BARYTES.

This earth is a virulent poison. Some of its salts have been long employed in mixtures prepared to kill rats. I do not know that any human being has been poisoned by it; but since it is a substance which is coming into common use as a useful chemical test, it is proper that the means of detecting it should be generally known.

If you add a drop of *sulphuric acid* or of a solution of *sulphate of soda,* to the most dilute solution of barytes, you cause the immediate production of a white precipitate; and if you add to the precipitate a little muriatic acid, the precipitate continues undissolved. But when you test thus an unknown liquid with sulphuric acid and muriatic acid, the production of such an insoluble white precipitate does not demonstrate the presence of barytes, because there are three substances which share with barytes the property of precipitating with sulphuric acid. These substances are lead, lime, and strontian. I have shown in what manner lead can be distinguished from barytes (p. 8). When it is known that lead is not present, the following experiments are sufficient to discriminate the two other substances. Add to the unknown liquid a solution of *sulphate of lime.* If a precipitate is produced, the solution contains barytes or strontian. Add to the un-

known liquid, a solution of sulphate of strontian. If a precipitate is produced, the solution contains barytes.

When barytic salts are contained in solutions with much organic matter, a precipitate is produced by diluted sulphuric acid, even when the liquids are very darkly coloured. The solution to be tested is first to be made acid by the addition of a little muriatic acid. When barytes is to be detected in solid or pasty organic substances, they must be boiled in a flask with water acidulated by nitric acid; the solution must be filtered through a paper filter placed in a glass funnel, and afterwards tested with sulphuric acid. The precipitate obtained by proceeding in this manner requires to be analysed before the operator can be *sure* that barytes is contained in it. The precipitate with this view is boiled in a glass flask with a solution of carbonate of soda, and the solution is filtered while hot through a paper filter. The powder which then rests on the filter is dissolved in muriatic acid, and the resulting solution is filtered and tested for barytes by diluted sulphuric acid.

When the compound for examination contains insoluble sulphate of barytes mingled with pasty or solid organic substances which are not soluble in pure water, it is best to proceed as follows:—Put the whole mass into a Hessian crucible, and cautiously and gradually heat the crucible in a fire. Raise the heat at last as high as you can. By

a good red heat the charcoal of the organic matter is made to reduce the sulphate of barytes to sulphuret of barium. When the ignited mass is cold, transfer it from the crucible to a glass flask, and boil it with water. Filter the resulting liquid and mix the clear solution with muriatic acid, adding it a little at a time, until the liquor ceases to smell of sulphuretted hydrogen. The presence of barytes is then readily detected by the addition of diluted sulphuric acid.

LIME.

This earth is capable of occasioning death when introduced in large quantity into the human body. It is the basis of chalk, whiting, and gypsum (otherwise called plaster of Paris, or sulphate of lime), which compounds are introduced by fraudulent tradesmen into numerous substances employed in the useful arts.

Such of the compounds of lime as are not soluble in water can generally be dissolved by muriatic or nitric acid, and the resulting *solution* can be exposed to the action of the re-agents.

When the solution of a compound containing lime is mingled with so much organic matter as to be very deeply coloured, the best way to detect the lime, is to mix the solution with a small quantity of a solution of commercial superoxalate of potash, and to add a little liquid ammonia. Should the solution be very acid, you must previously

neutralise it by ammonia; should it be very alcaline, you must previously neutralise it by muriatic acid. But when the test is added, the solution must always be made alcaline. By proceeding in this manner, you produce a precipitate of oxalate of lime, which though naturally white, often possesses a very dark colour when formed in this manner. Warm the solution for an hour or two, to make the precipitate subside, then filter it through paper, bring the precipitate upon the filter, wash it, dry it, and finally heat it to redness in a metallic crucible or in a piece of platinum foil. Put the ignited mass in a glass vessel, mix it with a little water, and add a small quantity of muriatic acid; make the solution slightly alcaline by adding ammonia, and then precipitate the lime again by adding a solution of superoxalate of potash. Allow the precipitate to subside, pour off the solution and divide the precipitate into several portions. Add to these separately, muriatic acid, nitric acid, and vinegar. The precipitate should dissolve in the two former, but not in the latter.

I have described (p. 43) in what manner lime is to be distinguished from lead, barytes and strontian, with which it is liable to be confounded.

When lime, or a salt of lime, is mingled with solid or pasty organic substances, the mass must be boiled in water acidulated with nitric acid. The acid solution is filtered from the insoluble matters, and is neutralised and

tested for lime in the manner described above. When sulphate of lime is mingled with solid or pasty organic substances which cannot be dissolved by pure water, the mass must be treated in the same manner as if it contained sulphate of barytes. The operation which it is necessary to perform, has been described (p. 44). The process referred to furnishes a muriatic acid solution, which is to be neutralised by ammonia, and tested with a solution of commercial superoxalate of potash in the manner described above.

ALUMINA.

This earth is the basis of all descriptions of clay, and forms nearly the entire mass of pure white pipe-clay. It is also contained in alum, a salt which is greatly in vogue as an adulterant. It is not exactly a poison, but it is a substance introduced into various articles of food, in such large quantities as must unquestionably render them extremely injurious to health; on this account it is highly necessary to be acquainted with the manner of detecting it.

As alumina is a substance which does not dissolve in water, it can be separated from many other substances by the mere aid of water. Thus, when adulterated sugar-plums, which often contain *half their weight of pipe-clay*, have to be examined, it is merely necessary to pound them, and mix the powder with a large quantity of water; whereupon, the sugar dissolves and the alumina gradually

falls to the bottom of the vessel. And when also, adulterated bread or flour is boiled in water, the bread or flour forms a pap, while the pipe-clay they contain, sinks to the bottom of the vessel. When the precipitate thus formed is collected together and made red-hot in a tobacco-pipe, it forms a substance as hard and as brittle as brick. This is a sure test of the presence of alumina.

When alumina is contained in a solution which is free from organic matter, it behaves towards re-agents as follows:—No free *acid* can produce a precipitate. A solution of caustic *potash* produces a bulky precipitate, which re-dissolves in a larger quantity of potash. Liquid *Ammonia* produces a precipitate, which does not dissolve in a larger quantity of ammonia. Solutions of *carbonate of potash* and *carbonate of ammonia*, act exactly like ammonia, but if the solution of alumina is concentrated, they occasion an effervescence to take place. A concentrated solution of alumina, when mixed with a solution of carbonate of potash and a slight excess of sulphuric acid, deposits crystals of alum after a little delay. These are recognised by their octahedral form and peculiar styptic taste.

But when a solution of alumina contains much organic matter, especially of that sort which cannot be volatilised in an undecomposed state by heat, but suffers decomposition when raised to an elevated temperature, and leaves a large residue of charcoal, the pre-

sence of the alumina is often incapable of detection by the usual re-agents, even though the solution be not coloured by the organic matter. Ammonia and solutions of carbonate of potash, and carbonate of ammonia, are incapable of precipitating alumina from such solutions, even when added in very great excess. Neither can crystals of alum be produced by the addition of potash and sulphuric acid. The presence of alumina in solutions which contain much organic matter, can therefore be detected, only by evaporating the solutions to dryness and igniting the residue to destroy the organic matter. You boil the solution to dryness in a Wedgewood's-ware capsule, and heat the residue to redness in a platinum crucible or spoon, held in the flame of a spirit lamp. The dry mass left by the ignition is boiled with muriatic acid, slightly diluted with water. The boiling is effected in a flask over a lamp. The solution thus prepared is diluted with water, and filtered through paper, and the filtered solution is tested for alumina by the re-agents cited above. If alumina be contained in solid or pasty organic substances, these must likewise be destroyed by exposure to a red-heat, and the residue be treated in the manner just described. Alumina is much more difficult of solution in acids *after* ignition than *before*.

The identity of alumina or pipe-clay can be demonstrated by the blowpipe as follows:—heat a small portion of the clay on charcoal before the blowpipe, then moisten it with a

drop of a solution of nitrate of cobalt, and again heat it strongly in the blowpipe flame. This will cause a fine blue colour to be communicated to the alumina. This experiment must be performed by daylight.

POTASH.

One of the compounds of potash, called nitre, saltpetre, sal-prunelle, and nitrate of potash, is much employed in the arts. It is a dangerous poison. It has frequently been mistaken for the saline laxatives, particularly for the sulphate of soda, and has thus been the source of fatal accidents. Pearlashes or carbonate of potash is frequently used in domestic economy, as well as in the arts. As an adulterant, it is added to wine and beer to saturate the acetic acid which forms in those liquids; in which case, acetate of potash remains in the adulterated liquids, and is liable to detection.

When the salts of potash are contained in solutions with much organic matter, the presence of the potash can be detected, even in liquids which are very deeply coloured, by the addition of small portions of the solutions of *tartaric acid,* and *chloride of platinum.* The former produces a white crystaline precipitate of supertartrate of potash, which appears the sooner in proportion as the liquor is the more concentrated. The latter produces a bright yellow precipitate of chloride of potassium and platinum. The production of the latter precipitate is promoted by the ad-

dition of a little alcohol to the solution. When an organic substance of a pasty or solid consistence is to be tested for potash, it can be macerated in water, or in diluted muriatic or nitric acid; but if the quantity of the substance be not considerable, it is best to char it in a Hessian crucible at a moderate heat, and to treat the charred mass with water or muriatic acid. The presence of potash can then be detected in the filtered solution, by applying the re-agents which have been cited above.

When an organic solution which contains nitrate of potash is evaporated to dryness, and the dry mass is thrown into a red-hot crucible, or upon red-hot coals, it deflagrates or makes an explosion, accompanied by the production of a great number of sparks of fire.

SODA.

This alcali, or its metallic basis *sodium*, is a constituent of common table salt, and therefore is a substance with which we often come into contact. Carbonate of soda is used in the washing of clothes, in the adulteration of wine and beer, and in many other cases where carbonate of potash is often employed. Sulphate of soda is in common use as a purgative. Caustic soda is poisonous, and so are all its compounds if taken in large quantities and in a concentrated state.

If salt of soda is present in a solution which contains no organic substances, the soda may be easily detected as follows:—Evaporate the

solution to dryness, fix a bit of the dry residue on the point of a very clean platinum wire and expose it to the extremity of the blowpipe flame. After all the moisture is driven away, the soda will give a long yellow flame, extending to a considerable distance on that side of the soda which is farthest from the blowpipe. No other substance in nature gives a long yellow flame in similar circumstances, after having undergone ignition. This is the only test for the presence of soda. There is no substance which is capable of precipitating it from solution. When *potash* is exposed to the blowpipe, it exhibits a *short violet-coloured* flame.

To detect soda, or its salts, in solutions which contain much organic matter, you must proceed as follows:—Evaporate the solution to dryness, and expose the dry residue in a Hessian crucible to a moderate red heat, in order to char it. Macerate the charred mass in very dilute nitric acid, filter the solution, and evaporate it to dryness, taking care to avoid inhaling the fumes of nitric acid, which fly off towards the end of the process. Then, to detect the soda, heat the dry substance produced by the evaporation, before the blowpipe, as described above.—A pasty or solid organic substance, in which the presence of a considerable quantity of soda is suspected, is to be charred and lixiviated precisely in the same manner.

If the same solution contains both potash and soda, the former must be detected in so-

lution by means of chloride of platinum, and the latter in the dry way by means of the blowpipe.

SULPHURIC ACID.

This compound, the *oil of vitriol* of commerce, is the strongest of all the acids. On account of its acidulating power and extreme cheapness, it is frequently made use of to give strength and roughness of taste to a variety of compounds employed in domestic economy, particularly to beer, vinegar, and pickles. As a constituent of alum, green vitriol, and other compounds, it enters as an adulterant into bread, beer, gin, and many other useful articles.

The Presence of Sulphuric Acid in Solution is very easy of Detection.—Add to the suspected liquid a few drops of a dilute solution of *chloride of barium.* This produces a white precipitate, which is the more copious and dense, the less the liquor is diluted. But for various reasons the test should always be added to a diluted solution. The precipitate must undergo the following examination.

Experimental Examination of a Precipitate suspected to consist of Sulphate of Barytes.—1. After the powder has subsided, pour off the clear liquor and add to the precipitate a little muriatic acid. If the precipitate dissolves, it will be demonstrated that no sulphuric acid is present.—2. Wash the precipitate on a paper filter and dry it. Mix a grain or two of it with a little dry charcoal powder; put the

mixture into a platinum spoon or a fold of platinum foil, and heat it for two minutes before the blowpipe. Mix the ignited powder with a little water at the bottom of a small glass tube, add a few drops of muriatic acid, and immediately hold in the tube above the mixture, a slip of white paper, moistened with a solution of nitrate or acetate of lead. The white paper will be blackened by the sulphuretted hydrogen gas disengaged from the mixture, which may also be generally discovered by the smell of rotten eggs which accompanies it.—3. Take a bit of the precipitate as large as the head of a common pin, mix it with twice as much carbonate of soda, place it on charcoal and expose it to the inner or reducing flame of the blowpipe. After keeping the mixture powerfully ignited for about a minute, remove it from the charcoal to a bright shilling or other piece of silver and add a drop of water to it. Let it rest a few minutes and then wash it off. If the precipitate contained sulphuric acid, the silver will be stained black or brown.

Treatment of Sulphates which do not dissolve in Water.—Dissolve them, if possible, in diluted muriatic acid. Dilute the solution with water, filter it, and then proceed as above. If they cannot be dissolved by muriatic acid, they must be treated with carbonate of soda in the manner described (p. 44).

Detection of Sulphuric Acid in vegetable or animal Mixtures.—When free sulphuric acid is present in solution with vegetable or

animal substances, it often happens that a portion of the sulphuric acid escapes precipitation by the solution of chloride of barium. This is the case, for example, when a mixture of sulphuric acid and alcohol is the subject of experiment. But the quantity of sulphuric acid which can be present in a liquid without giving a slight precipitate with a solution of chloride of barium, must, under any circumstances, be extremely small.

Many organic solutions, on being tested with a solution of chloride of barium, produce a precipitate which is very liable to be mistaken for sulphate of barytes. This precipitate is the malate of barytes, which is often produced in such liquors as beer and vinegar, upon the addition of chloride of barium with a view to detect sulphuric acid. The malate of barytes can be distinguished from the sulphate of barytes by the following experiments. Wash and dry it on the paper filter; heat it to redness in a crucible or clean tobacco-pipe; mix it after ignition with a little water, and add a few drops of muriatic acid to the mixture. If the solid matter dissolves, the precipitate was malate of barytes; if it remains undissolved, it was sulphate of barytes.

Detection of Sulphuric Acid in solid Organic Substances.—When a piece of cloth or any solid matter is suspected to contain sulphuric acid, you must boil it for a few minutes in a Florence flask with distilled water, then filter the solution and apply the

test to the clear liquor. It is sometimes necessary to add muriatic acid to the water in which the solid matter is digested.

NITRIC ACID.

This is the chemical name for the most powerful kind of *aquá-fortis*. The way to know whether a liquid contains free nitric acid is to add copper filings or tin foil to it. All sorts of aqua-fortis except the very strongest and the very weakest, give out red fumes when mixed with these metals. Nitric acid communicates a yellow colour to organic matters, such as the corks of bottles or the skin of the human body.

When you have a solution containing a small quantity of a nitrate or salt containing nitric acid, evaporate the solution to dryness by a very gentle heat, and examine the salt in the dry state by the processes which follow. When you have a solution containing *free* nitric acid, neutralise it with a solution of potash, and then separate the nitrate of potash by evaporating the solution to dryness. If you have a large quantity of nitrate of potash in solution, you can partially separate it in the state of crystals by concentrating the solution and setting it aside to crystalise.

To determine whether a dry Substance contains a Nitrate.—Mix a little with charcoal powder, and project the mixture into a red-hot tobacco-pipe. If the mixture deflagrates or emits sparks of fire, the presence of a nitrate may be suspected, but there are

several other classes of salts which deflagrate under the same circumstances. Mix it in a glass tube with copper-filings and add a little sulphuric acid. If a nitrate is present, the mixture disengages an orange-yellow vapour. If sulphuric acid, without copper filings is added, a colourless acid vapour is disengaged; this produces white clouds when a glass rod moistened with ammonia is held over the mixture.

To determine whether a Solution contains Nitric Acid or Nitrates.—Add to the solution, a bit of *gold-leaf*, and a little muriatic acid. The gold dissolves if nitrates are present, but not otherwise.—The blue liquor produced by dissolving indigo in sulphuric acid is deprived of colour when boiled with solutions of nitrates. The mixture should be acid and of a pale blue. Many other salts besides nitrates have the same effect. The boiling may be effected in a small glass tube over a candle.—Add to the solution, a small quantity of sulphuric acid, and then a clean crystal of green copperas (protosulphate of iron). Warm the mixture. If a nitrate is present, the liquid near the crystals acquires a dark blackish brown colour. In very dilute solutions, this colour is scarcely perceptible; but when the nitrate is present in large quantity, the colour tinges the whole solution.

Solid organic substances suspected to contain nitric acid must be macerated in cold water. It is dangerous to apply heat, because a prolonged digestion in company with

organic substances, converts nitric acid into malic and oxalic acids.

When a solution contains a large quantity of animal matter with only a small quantity of nitrate of potash, it is advisable to proceed as follows:—Evaporate the solution nearly to dryness and mix it with alcohol. This precipitates a considerable proportion of the animal matter. Filter the solution and seek for the nitric acid in the clear liquor.

One of the properties of strong nitric acid ought not to be overlooked by the "Domestic Chemist." If applied in small quantities to warts on the fingers it speedily and effectually removes them. At the first application the skin turns yellow; when a little more acid is added, a commotion resembling effervescence takes place; and after a few days the wart dries up and finally falls off. Sometimes two or three applications of the acid are necessary.

MURIATIC ACID.

This is the chemical term for the liquid usually called *spirits of salt.*

To detect Muriatic Acid in Solutions.—Add a solution of nitrate of silver. If muriatic acid is present a copious white flocky precipitate will be produced. The solution should be slightly acidulated with nitric acid and filtered. The precipitate should behave as follows:—A portion placed in the sun, should blacken; put into dilute nitric acid, it should remain unaltered; put into liquid am-

monia, it should dissolve. Dried and fused in a glass tube, it should produce a substance resembling horn both in colour and texture.

To detect Muriatic Acid (or Chlorine) in solid Substances.—Mix the substance with sulphuric acid and heat it. If chlorine or muriatic acid is present, the mixture effervesces and discharges muriatic acid gas. If a rod moistened with ammonia is held near, white clouds are formed.—Mix the substance with sulphuric acid and peroxide of manganese, if chlorine or muriatic acid is present, chlorine gas is disengaged. This is known by its yellow colour, stinging odour, and its property of bleaching moistened litmus paper.

The following is a very delicate experiment for detecting chlorine in solid substances. Twist the end of a fine copper or brass wire into a little ring one-twelfth of an inch in diameter; fuse in this ring a small quantity of microcosmic salt or of phosphate of soda. This salt melts easily over the flame of a lamp. The bead should have a pale green colour. If you heat it too much it becomes opaque and red, in which case it does not answer the intended purpose so well. Apply to the green bead, the smallest possible portion of any substance which contains chlorine, and expose the bead to the extremity of the flame of the blowpipe. You will immediately perceive a splendid bluish-purple flame dart off from the substance which contains the chlorine.

The hundredth of a grain of a solid chloride can be tried in this manner. The expe-

riment succeeds even with the volatile chlorides, such as muriate of ammonia, and chloride of mercury. It is a good method of proving the presence of chlorine in the precipitates produced by nitrate of silver, being easy of application and perfectly decisive.

The presence of non-volatile organic substances in a solution, does not prevent the precipitation of muriatic acid by the solution of nitrate of silver.

As common salt contains chlorine, any organic mixtures which may contain common salt will act towards a solution of nitrate of silver, exactly in the same manner as if they contained free muriatic acid. This circumstance may produce ambiguity in some cases. The presence of free muriatic acid in a liquid may be demonstrated by submitting it to distillation, upon which the free acid will pass over into the receiver, whereas the common salt will remain in the retort. See the article "*Vinegar*," in a subsequent section.

Caution.—If you wish to detect muriatic acid in a solution which may probably contain sulphuric acid, you must not employ a solution of nitrate of silver, because this re-agent precipitates both muriatic and sulphuric acid. The proper re-agent to make use of is a concentrated solution of sulphate of silver, which precipitates muriatic acid but not sulphuric acid. Or you may first precipitate the sulphuric acid by a solution of nitrate of barytes.

PRUSSIC ACID.

As several liquids are employed in common life, which possess properties that are due to the presence of prussic acid, and as death has frequently been produced by the administering of these liquids, either wilfully or accidentally, it is proper to take some notice of the methods which may be employed in demonstrating the presence of prussic acid. The liquids in common use which contain prussic acid, are the various oils and aromatic waters produced from the bitter-almond, the cherry-laurel, the peach-blossom and the cluster-cherry. The liqueur termed Noyeau is a weak poison of this description, and all tarts and jellies which are flavoured by laurel leaves are to a certain extent poisonous.

Detection of Prussic Acid by the Smell.—Solutions of prussic acid possess a peculiar odour which, though resembling that of bitter almonds, is accompanied by an impression of acridity in the nostrils and back of the throat. The odour is very powerful even in dilute solutions of prussic acid, and constitutes a good means of detecting it. Nevertheless, some persons are unable to perceive this odour unless it is particularly strong, so that the test is one which cannot be depended upon by all inquirers.

Detection of Prussic Acid in Solutions which are free from organic Substances.—1. A solution of *nitrate of silver* produces a white precipitate which is the cyanuret of silver. This

precipitate should be gathered on a filter and washed with pure water. It is distinguished from other white precipitates of silver by being insoluble in cold nitric acid, but soluble in boiling nitric acid. It is also characterised by the following property. If dried, then inserted in a small glass tube, and exposed to heat, it gives out cyanogen gas, which if inflamed at the mouth of the tube (which should be drawn out to a fine point after the insertion of the precipitate) burns with a crimson-coloured flame.—2. Add a solution of sulphate of protoxide of iron mixed with sulphate of peroxide of iron, a solution of which kind may be prepared by boiling a solution of common green vitriol with a few drops of nitric acid. This solution produces a Prussian-blue precipitate in solutions of prussic acid.

Detection of Prussic Acid in Solutions which contain vegetable or animal Substances.—1. Dip a piece of unsized white paper first into a solution of caustic potash, and then into the mixed liquor suspected to contain prussic acid; dry the paper and then moisten it with a solution of sulphate of iron: the production of a greenish blue colour indicates the presence of prussic acid.—2. From syrup and many other solutions, the prussic acid can be separated by dilution with water and precipitation by a solution of nitrate of silver. The precipitated cyanuret of silver is apt to be accompanied by other compounds of a similar appearance. It must consequently be examined

by the methods given above.—3. Filter the organic solution; if it is alcaline, neutralise it with sulphuric acid; pour it into a retort, to which join a receiver with such accuracy as to fit air-tight; then apply a gentle heat to the retort and distil over one-eighth part of the liquid contained in it. Let the whole cool: the liquid in the receiver will consist of water and prussic acid. The latter may be detected by means of the solutions of nitrate of silver and of mixed sulphates of iron, as described in a preceding paragraph.

The production of the Prussian-blue precipitate with the mixed sulphates of iron, and of the crimson-coloured flame by burning the gas disengaged from the ignited cyanuret of silver, are the tests least liable to ambiguity.

A few remarks relating to the substances which contain prussic acid may not be out of place here.

The Bitter Almond.—Its essential oil is an extremely powerful poison. A single drop of it killed a cat in five minutes. The bitter almond is used by confectioners for flavouring puddings, sweetmeats and liqueurs. Accidents occasionally happen among children at Paris, from their eating too freely of macaroons, which are flavoured with the bitter almond. This vegetable often produces in man a state resembling intoxication, and sometimes an eruption like nettle-rash; it has been often the cause of death.

The Cherry-Laurel, or *Prunus Lauro-cera-*

sus, was at one time much employed for flavouring liqueurs and sweetmeats. Many persons have been killed by ratafiad brandy, and by custards flavoured with laurel leaves. The plant yields a volatile oil, the solution of which in water constitutes cherry-laurel water. Both are poisonous. Foderé gives an account of a servant who stole a bottle of cherry-laurel water, and mistaking it for a cordial, drank it speedily and died. This was the poison employed by Captain Donnellan for the murder of Sir Theodosius Boughton.

The *Peach*.—Most parts of the plant exhale the odour of the bitter almond, but particularly the flowers and the kernels. An elderly gentleman swallowed a sallad of the flower to purge himself: he was soon afterwards seized with giddiness, purging, convulsions and stupor; in three days he died. A child eighteen months old, took a decoction of the flower to destroy worms, and perished in frightful convulsions.

The *Cluster-cherry*, or *Prunus Padus*.—It has a disagreeable taste, but gives a pleasant flavour to spirituous liquors. It is highly poisonous; its volatile oil containing more prussic acid than is contained even in cherry-laurel water.

The prussic acid is also contained in the black cherry, the bullace, the sloe, the dwarf almond, in the leaves and kernels of the common cherry, and most probably in the seeds of the apple and pear.

OXALIC ACID.

Although this poison is ill adapted to the purposes of the murderer, it is probable that more deaths are produced by its means than by any other of the powerful poisons. In general, it has been mistaken for Epsom salts by those who have suffered by it.

Instructions for detecting the Presence of Oxalic Acid or of Oxalates.—1. If the oxalic acid or the oxalate is in a solid state, put a little of it into a glass tube, add to it rather more concentrated sulphuric acid than is sufficient to saturate the base of the oxalate, and then gently heat the mixture over a lamp. A rapid disengagement of gas takes place, which gas is a mixture of carbonic acid and carbonic oxide. The latter can be inflamed at the mouth of the glass tube, whereupon it slowly burns with a blue flame.—2. If the oxalic acid or the oxalate is dissolved in water, add to the solution a solution of sulphate of lime. This will produce a white granular precipitate of oxalate of lime. But this experiment is equivocal, unless you previously add to the oxalic solution, a few drops of a solution of some other sulphate. This is necessary to ascertain whether any barytes or strontian is present in the oxalic solution; because both of these earths act towards the solution of sulphate of lime in the same manner as solutions of the oxalates act.

To bring insoluble oxalates into solution, boil them with water and carbonate of potash,

filter the solution while hot, and neutralise it with nitric acid. Then apply the test for oxalic acid.

To detect Oxalic Acid in vegetable and animal Mixtures.—When a person is suspected to have been poisoned by oxalic acid, the truth of the matter may be ascertained by analysing the vomited matter, and the contents and tissues of the stomach. The operation is as follows:—

(*a*) Dilute the mass with distilled water and boil it gently for an hour; then neutralise the solution by potash and filter it, first through muslin and then through paper.

(*b*) Boil the insoluble matter for half an hour in a dilute solution of carbonate of potash; then filter the solution and neutralise it with nitric acid.

(*c*) The above processes furnish solutions containing oxalates of alcalies accompanied by organic matter. To separate the oxalates from the organic matter, add a solution of chloride of calcium and take care to keep the solutions alcaline and hot. After five or six hours' repose, filter the solution, collect the precipitated oxalate of lime upon the filter, and wash it clean.

(*d*) The resulting oxalate of lime is to be analysed according to the instructions contained in the preceding page.

OPIUM.

Opium is the essential constituent of laudanum, the black drop, Battley's sedative liquor,

and numerous other preparations of frequent employment in medicine. "It is," says Dr. Christison, "a poison of the greatest importance to the medical jurist, since there is scarcely any other whose effects come more frequently under his cognizance. It is the poison which is most generally resorted to by the timid to accomplish self-destruction, for which purpose it is peculiarly well adapted on account of the gentleness of its operation. It has also been often the source of fatal accidents, which naturally arise from its extensive employment in medicine. It has likewise been long very improperly employed to create amusement. And in recent times it has been made use of to commit murder or to induce stupor previous to the commission of robbery."

Instructions for the Detection of Opium in vegetable and animal Mixtures.—Cut or pound the solid matters into pulp, add water if there is not a large quantity of liquid already present; acidulate the mixture with acetic acid; stir up the mixture; let it settle a few minutes; filter it, and evaporate the clear liquor by a gentle heat till it forms a moderately thick extract. Mix this with strong alcohol, break down any lumps which may be produced, boil the mixture, let it cool, and filter it. Evaporate the clear liquor till it forms a thin syrup, dilute it with water, and again filter it. Add to the clear liquor a solution of subacetate of lead, as long as it produces a precipitate. Let the whole settle, filter the precipitate and wash it. The process now divides into two.

(*a*) Pass into the filtered solution a current of sulphuretted hydrogen gas. This throws down the excess of lead in the state of sulphuret. Separate the precipitate by filtration. If the filtered solution is still coloured, put it into a bottle with some animal charcoal, shake it well, and filter it; then concentrate it by evaporation. 1. If it has a bitter taste, it shows the presence of morphia (the most important constituent of opium). 2. Add a drop or two of a solution of perchloride of iron. If morphia is present, a dirty indigo-blue colour will be produced. 3. Evaporate a portion of the solution to dryness and add a little nitric acid to the dry residue. If morphia is present, an orange-red colour will be produced.

(*b*) Suspend the precipitate produced by the subacetate of lead, in a small portion of water, and pass a current of sulphuretted hydrogen gas into the mixture till the whole precipitate becomes black; then filter the solution, boil the clear liquor, and if it becomes turbid, filter it again. Once more precipitate the solution by a solution of subacetate of lead, separate the precipitate by filtration and treat it with sulphuretted hydrogen in the manner just described. This repetition of the process is necessary to purify the meconic acid (another constituent of opium) which forms part of the insoluble powder thrown down by the subacetate of lead. The solution filtered from the sulphuret of lead contains the meconic acid in a state of purity; it must be concentrated by

evaporation and then exposed to the following tests.—1. Add to a portion of the solution a solution of perchloride of iron, which will produce an intense cherry-red colour.—2. The addition of a solution of sulphate of copper produces a pale green precipitate.—3. Evaporate a portion of the solution very strongly, but not to dryness. As it cools, it will deposit the meconic acid in pale yellowish brown scaly crystals. Heat a few of these crystals in a glass tube. They will give an arborescent radiated sublimate of crystalised acid.

I cannot promise an unpractised experimenter that he shall detect opium at the first trial, even if he have a large quantity to operate upon. The detection of organic substances in organic mixtures requires a degree of skill in manipulation much greater than that which is requisite for the detection of mineral substances.

THE DOMESTIC CHEMIST.

PART II.

Instructions for the Examination of Articles supposed to be Adulterated.

Acetic Acid.—(*a.*) *Pure Acetic Acid.* It should have a specific gravity of 1·063, that of water being 1·000. When heated in a spoon it should take fire from a burning paper, and ought to volatilise with great rapidity. It ought to be perfectly colourless, should have a pure strong acid odour, which ought not to be empyreumatic or sulphurous. It must give no precipitate with a solution of chloride of barium, otherwise it contains sulphuric acid. If when neutralised with ammonia and tested with a solution of chloride of barium, it gives a precipitate which dissolves in nitric acid, it contains sulphurous acid. It must give no precipitate with a solution of nitrate of silver, otherwise it contains muriatic acid. When nearly neutralised

by an alcali, it must give no precipitate with prussiate of potash, liquid sulphuretted hydrogen or hydrosulphuret of ammonia, otherwise it contains a poisonous metal. It ought to be diluted with water, before these reagents are added. When heated on a watch-glass, it should volatilise without residue.

(*b.*) *Distilled Vinegar*. It must be a perfectly colourless liquid, and must possess an agreeably acid taste and smell, free from empyreuma. It must evaporate when heated in a watch-glass, without leaving any residue. Neutralised by ammonia, it must remain transparent. If it gives a white precipitate which partially re-dissolves in an excess of ammonia, it contains tin; if the precipitate is permanent, it contains lead. When nearly neutralised by ammonia and tested with a solution of yellow prussiate of potash, if it gives a red precipitate it contains copper, if it gives a white precipitate, it contains tin. When supersaturated with ammonia, if it turns blue, it contains copper. It must give no precipitate with liquid sulphuretted hydrogen. It must give no white precipitate with sulphuric acid, otherwise it contains lead. It ought to neutralise one-eighth of its weight of carbonate of soda.

(*c.*) *Common Vinegar*. The adulterations usually present in bad vinegar are the following:—Acrid vegetable substances, sulphuric acid, muriatic acid, nitric acid, copper, lead, and a large quantity of water.

To detect acrid vegetable Substances in

Vinegar.—To make weak vinegar *taste strong* it is customary to soak in it Guinea pepper, mustard seed, grains of Paradise, pellitory of Spain, and other acrid vegetable substances. These can be detected as follows:—1. Mix the vinegar with carbonate of potash till the mixture is neutral and no longer reddens litmus paper. Then taste it, the acid taste of the vinegar will be imperceptible; but the burning taste of the acrid vegetables will remain.—2. Moisten the upper lip with pure vinegar, and the lower lip with the suspected vinegar, suffer the vinegar on the two lips to evaporate in the air. If the suspected vinegar contains any pungent vegetable substances, the taste of these substances will remain after the total evaporation of the vinegar.

To detect Sulphuric Acid.—Evaporate by a gentle heat the suspected vinegar till it is reduced to the eighth part of its original bulk. If the residue possesses a powerful caustic taste, it indicates the presence of sulphuric acid. Mix the concentrated vinegar with five or six times its bulk of spirit of wine, and filter it through paper to separate any precipitate which may be formed. This operation removes from the vinegar the small portion of sulphate of lime which exists in it naturally and not as an adulteration. Slowly evaporate the filtered solution to separate the alcohol, previously adding to the mixture an equal bulk of water. When the alcohol has apparently all escaped, the liquid is to be tested with a few drops of a solution of *chloride of*

barium, which, if free sulphuric acid is present, instantly produces a dense white precipitate; whereas no precipitate is produced if the vinegar is pure. The fact that the resulting precipitate really contains sulphuric acid is to be proved in the manner related at page 53. Many authors prescribe the direct addition of the solution of chloride of barium to the adulterated vinegar; but the formation of sulphate of barytes does not in that case unequivocally prove the existence of free sulphuric acid in the vinegar operated upon; for many species of vinegar contain the sulphates of lime and potash as natural constituents; in small quantity it is true, but yet in sufficient quantity to produce a precipitate with a solution of chloride of barium. Consequently it is better and safer to follow the process described above, in which nothing is left to be guessed at. The adulteration of vinegar with sulphuric acid is practised to a great extent.

To detect Muriatic Acid. Add to the suspected vinegar a solution of *sulphate of silver*. If a white curdy precipitate is formed, allow it to settle, decant the solution, and divide the precipitate into two portions. To one of these, add nitric acid, to the other, add ammonia. If the precipitate dissolves in ammonia but not in nitric acid, the experiment demonstrates the presence of muriatic acid in the vinegar. But since vinegar is apt to contain muriates or chlorides as natural constituents, it is necessary to determine by a separate experiment, whether the vinegar contains *free* muriatic

acid or merely the small portion of combined acid which belongs to the native salts. To settle this question, you must distil a portion of the suspected vinegar, and test the distilled portion with the solution of sulphate of silver. If you still obtain a precipitate possessed of the characters above described, and which characterise the compound termed chloride of silver, you may safely conclude that the vinegar submitted to trial really contains muriatic acid. Some authors recommend you to test vinegar for muriatic acid by the addition of a solution of *nitrate of silver*. But since vinegar is liable to contain much sulphuric acid, with which nitrate of silver gives a precipitate as well as with muriatic acid, the use of this re-agent is liable to give ambiguous results. It is necessary, therefore, either to employ a solution of sulphate of silver, or previously to separate all the sulphates and sulphuric acid from the vinegar, by the careful addition of a solution of acetate of barytes. This affords a precipitate of sulphate of barytes, which can be separated from the vinegar by filtration. The nitrate of silver may afterwards be applied with safety.

To detect Nitric Acid. Neutralise a portion of the vinegar by adding a solution of carbonate of potash, then evaporate the mixture to dryness. Throw a little of the dry mass into a red-hot crucible, or upon red-hot coals. If a deflagration takes place, the presence of nitric acid is proved. Mix a little of the dry mass with copper filings, put the mixture into a

small glass, and add a few drops of strong sulphuric acid. If red fumes are produced, it denotes the presence of nitric acid. The employment of nitric acid to adulterate vinegar takes place very rarely.

To detect Water. When vinegar is adulterated with a powerful acid, the intent is to enable it to bear a considerable dilution with water.

The best means of determining the presence of water appears to be that of ascertaining the strength or neutralising power of the pure acetic acid contained in the vinegar. A weighed quantity of carbonate of lime (white marble in powder for example) is gently heated in a Florence flask with a weighed quantity of the vinegar for examination, care being taken to have an excess of the carbonate of lime. The liquor must never be allowed to boil, but merely be heated moderately. When the action of the acid on the carbonate of lime appears to be at an end, the liquor is filtered through a paper filter, the precipitate is brought upon the filter, and after being well washed and strongly dried, is weighed with the filter. The weight of the filter, ascertained previous to the operation, is then deducted from the joint weight of the residual powder and the paper. The operator thus learns how much carbonate of lime has been dissolved by a determinate weight of vinegar, and since the strength of the vinegar is in direct proportion to its neutralising power as an acid, this operation gives an immediate solution of the proposed problem. Every grain of carbonate

of lime dissolved in such an experiment, indicates the presence of a grain of acetic acid in the vinegar which forms the solvent. Consequently, if a given weight of a particular sample of vinegar dissolves twenty grains of carbonate of lime, and the same weight of a different sample dissolves forty grains, the latter sample will be twice as strong as the former. Good wine vinegar is capable of dissolving rather more than the twelfth part of its weight of carbonate of lime.

To detect Potash. Vinegar often contains this alcali in the state of tartrate of potash. To detect it, evaporate the vinegar to dryness, heat the residue to redness, and expose the substance which is left to the tests for potash described at page 50.

To detect Metals. The metals most likely to be expected in vinegar are lead, copper, iron and tin. Make the solution nearly neutral by the addition of potash, but leave the acid in slight excess. Add liquid sulphuretted hydrogen to a portion of the solution. A black precipitate indicates lead, copper and tin. Add hydrosulphuret of ammonia to another portion. A greenish black precipitate indicates iron. Add a solution of yellow prussiate of potash. A red precipitate indicates copper; a blue precipitate indicates iron; a white precipitate indicates tin. Add sulphuric acid to the solution. A white precipitate indicates lead. Add a solution of chloride of gold: a purple precipitate indicates tin. You make these trials on small quantities of the vinegar

in little test tubes. When you think you have discovered lead, copper, or iron, you can for security sake, submit the vinegar to any of the other tests for these metals, which I have described in Part I.

ALCOHOL.—Pure alcohol is a transparent colourless liquid, the specific gravity of which is to that of water as 79 is to 100. It boils at the temperature of 173 deg. Fahr. It possesses a hot sharp taste and a peculiar strong and agreeable vinous odeur, which ought never to be empyreumatic. To examine the odour of alcohol, a few drops of it should be rubbed between the hands and allowed to evaporate. It very often happens that alcohol possesses a foreign odour, arising from other volatile liquids prepared at the same time in the same laboratory, or to the fact that the still in which the alcohol was prepared, possessed a foreign odour. Sometimes alcohol is rectified over animal charcoal instead of vegetable charcoal, burnt bones being improperly employed for this purpose; and occasionally alcohol acquires an ill smell from being kept in bottles secured by corks and pieces of bladder. This gives it the odour of anatomical preparations. It ought always to be preserved in bottles with ground-glass stoppers.

Good alcohol volatilises without residue, and when inflamed, burns away without residue and without smoke. The more concentrated it is, the brighter the flame it produces: the bluer the flame appears, the more water it contains. When diluted with water and

tested with a solution of chloride of barium it should give no precipitate, otherwise it contains sulphuric acid; neither should it give any precipitate with a solution of nitrate of silver, otherwise it contains muriatic acid. When concentrated by evaporation, it must not become alcaline, otherwise it contains potash. Alcohol very often contains sulphuric ether, the presence of which is best detected by its peculiar odour. If you wish to know whether alcohol contains water, put into it a piece of caustic barytes. If water is present the barytes becomes white and falls into a powder: if not, no change is produced.

Spirits of Wine. The alcohol of commerce, which is commonly termed *spirits of wine,* consists of pure alcohol debased by water and contaminated by various kinds of volatile oil, according to the nature of the substances from which it has been prepared. The alcohols separated from wine, malt, potatoes, starch, sugar, &c., differ from each other as well in specific gravity, as in their taste and odour. All these different sorts, however, can be converted into pure alcohol by proper rectification.

If you add to impure spirits of wine, ten times its bulk of water, the mixture becomes white and opalescent, in consequence of the separation of the oil to which the spirits of wine owed its impure odour. If you rub a little of the impure spirits between your hands, the oil leaves its odour upon the skin. Salts and fixed substances can be detected by boil-

ing away the alcohol and water, when the solid impurity remains behind.

Expressing the specific gravity of water by 100, and that of pure alcohol by 79, the specific gravity of a mixture of the two liquids must be expressed by some intermediate number, and this number must approach 100 or 79, just as water or alcohol forms the preponderating ingredient in the mixture. When you want to know the value of a particular sample of spirits of wine, the problem to be solved is, what is the proportion of alcohol which the spirits of wine contains? This problem is solved by means of an instrument called the *hydrometer*. This instrument consists of a bulb and tube of glass, the latter of which is furnished with a longitudinal scale. The hydrometer sinks deepest in the liquor which contains the most alcohol, and the strength of the liquor is denoted by the scale. The latter can be made to indicate, either the *specific gravity* of the liquor, or its *per centage* of alcohol. The hydrometers sold by the instrument-makers are accompanied with directions for using them.

Aloes.—Though all the better kinds of aloes bear the name of Socotrine, the fact is that the greater part are imported from Bombay. The best kind is an extract of the spiked aloe. This has a brilliant reddish brown colour, is very translucent at the edges, has a smooth conchoidal fracture, an aromatic agreeable odour, and an intensely bitter and nauseous taste. It affords a golden yellow powder.

The kind more generally met with, is more opaque, of a much darker colour, and more disagreeable odour and taste. Aloes are sometimes re-melted in this country, partly with a view to improve the tint and odour of the mass, and partly to afford an opportunity of deteriorating its quality by the admixture of common resin. This fraud is easily detected by the insolubility of such adulterated aloes in boiling water.

Barbadoes Aloes. Imported from Barbadoes in gourds, each of which contain about half a hundred weight. This is generally deeper coloured and more opaque than the Socotrine aloes; its consistence is tougher, its fracture less shining; its odour powerful and disagreeable; its powder dirty yellow. It has the reputation of acting more powerfully than the Socotrine aloes, and is on this account preferred in the preparation of horse-medicines, for which purpose enormous quantities of it are employed. Socotrine aloes is distinguished from Barbadoes aloes by dissolving entirely in boiling water and alcohol, whereas the other leaves a considerable residue.

Alum.—This salt is liable to contain iron, which is very injurious in calico-printing and in many other arts. To detect the presence of this metal, proceed as follows:—Dissolve a portion of the suspected alum in water, contained in a Florence flask, add a little nitric acid and boil the mixture. Let it cool, filter it, and add liquid ammonia to the clear solution. If iron is present, it will fall down in the form of a reddish brown powder.

The alum which is commonly met with is a sulphate of alumina and potash; other varieties occasionally appear in the market, in which the potash is replaced by soda or ammonia. These three sorts of alum may be distinguished as follows:—Expose a small portion to the flame of the blowpipe, and let it be done at night and when no other light is present besides that of the blowpipe lamp, which should be nearly extinguished by the mouth of the blowpipe. Soda alum produces a rich yellow flame, potash alum a weak violet flame, ammonia alum a transient green flame and an odour of ammonia.

Amber—Is sometimes mixed with various resins, and especially with fragments of copal, which are detected by their difference of fracture and colour, and by not exhaling the peculiar odour which amber does when put upon a hot iron.

Ammonia.—It should be a perfectly colourless liquid. When concentrated, its specific gravity should be 0·9. It must have a pure ammoniacal odour, and must volatilise without residue. It must not become troubled when mixed with alcohol, or with lime water, otherwise it contains carbonate of ammonia. Neither must it for the same reason become troubled when tested with a solution of chloride of barium; this is the prime test for carbonate of ammonia. Care is to be taken to observe the action of the test on its first addition, for after the mixture has been exposed to the air for a few minutes, a troubling

necessarily ensues because the ammonia abstracts carbonic acid from the atmosphere.

When supersaturated with nitric acid and tested with a solution of nitrate of silver, it must give no white precipitate, otherwise it contains sal-ammoniac. It must give no precipitate with a solution of chloride of barium, otherwise it contains sulphuric acid, in which case the precipitate will be insoluble in nitric acid. It must give no precipitate with a solution of oxalic acid or superoxalate of potash, otherwise it contains lime. When saturated with nitric acid and tested with a solution of yellow prussiate of potash, it must give no red precipitate, otherwise it contains copper. When mixed with its weight of oil of vitriol, it ought not to become brown or black, otherwise it contains empyreumatic oil.

As it is difficult to obtain ammonia quite free from carbonate of ammonia, or to preserve it in that state, the employment of ammonia containing a small portion of carbonate of ammonia is admissible in pharmacy.

AMMONIA, *Carbonate of. Preston Salts. Smelling Salts.*—This salt is perfectly white. It commonly forms very hard masses of a fibrous crystaline structure which effloresce and fall to pieces in the air. It is characterised by a strong ammoniacal odour, which, however, must not be disagreeable and empyreumatic. When heated in a platinum spoon, it must volatilise without leaving the least residue.

It must dissolve without residue in water and give a perfectly colourless solution, which

must behave towards re-agents as follows:—With a solution of nitrate of silver, it must produce a precipitate, capable of being re-dissolved by nitric acid, otherwise it contains sal-ammoniac. With a solution of chloride of barium, it must produce a precipitate soluble in nitric acid, otherwise it contains sulphuric acid. After neutralisation with nitric acid, it must produce no precipitates with liquid sulphuretted hydrogen, hydrosulphuret of ammonia, or solution of prussiate of potash, otherwise it contains lead, copper, or other metals. It has been stated in various books that carbonate of ammonia often contains lead, but this is a doubtful point. Should it be true, the adulteration ought to be carefully guarded against, since carbonate of ammonia is frequently employed by bakers in the preparation of bread. A considerable quantity of carbonate of ammonia is prepared from a liquor produced in gas-works. This kind has frequently a disagreeable odour from which it is difficult to free it.

Spirit of Hartshorn.—This is a compound of carbonate of ammonia with empyreumatic oil and water. This liquid is sometimes imitated by dissolving sal-ammoniac, potash and empyreumatic oil in water; in which case, hartshorn and distillation are alike dispensed with. The two compounds may be discriminated as follows.—1. Add muriatic acid to the liquid. If it is pure spirit of hartshorn, it will effervesce strongly.—2. Add alcohol to the liquid. If it is pure spirit of hartshorn,

it will give a coagulated precipitate of carbonate of ammonia.—3. Evaporate the liquid in a spoon. The false spirit will leave a residuum of chloride of potassium : the pure spirit leaves nothing or at most a minute quantity of charcoal.—Spirit of hartshorn commonly contains a little prussic acid. This may be proved as follows :—Neutralise the liquid by muriatic acid, and add a solution of sulphate of iron. The presence of prussic acid will be shown by the production of a blue precipitate.

AMMONIA, *Muriate of. Sal-ammoniac.*—When pure, this salt is totally volatilisable by heat. If a small portion on being heated on a piece of platinum foil over a spirit lamp, leaves any fixed residue, it is adulterated. It should dissolve entirely in water: if it leaves an insoluble residue, it is adulterated. The impurities generally found in sal-ammoniac are sulphate of ammonia, sulphate of soda, chloride of sodium, and chloride of potassium. Occasionally it contains lead, iron, and copper. The presence of sulphuric acid is to be detected by means of a solution of chloride of barium as described at p. 53, that of sodium by the processes described at p. 51, that of potassium as described at p. 50, of lead at p. 8, of iron at p. 40, and of copper at p. 2. Sal-ammoniac is known by giving out the odour of ammonia when mixed with caustic potash, and by showing the presence of chlorine when examined by the processes given at p. 58.

When sal-ammoniac possesses a brownish

colour, it indicates the presence of charcoal or empyreumatic oil. Such sal-ammoniac is very good for soldering and tinning, but not fit to be employed in medicine or chemistry.

When sal-ammoniac leaves a non-volatile residue, it may contain sulphate of soda or chloride of sodium. These substances are often found in unpurified sal-ammoniac to the amount of ten *per cent.*

When sal-ammoniac contains much sulphate of ammonia, it fuses and sputters before it sublimes; whereas it otherwise sublimes without fusing. When sal-ammoniac sublimes without residue, but gives a precipitate when its solution is tested with a solution of chloride of barium, it contains sulphate of ammonia; but when it leaves a non-volatile residue, the precipitate indicates sulphate of soda or sulphate of magnesia.

Anchovy Sauce.—This sauce is prepared by pounding anchovies to a pulp. The mass is often coloured by the addition of Venetian red, and as Venetian red is frequently adulterated with red lead, it follows that anchovy sauce must occasionally be rendered poisonous by *lead.* You may detect the presence of this metal by following the general process for the detection of lead, described at p. 11.

Angustura.—There are two sorts of angustura bark. The *true* angustura is a useful medicine, the *false* angustura is a violent poison. The two sorts are sometimes found in commerce, mixed together.—1. When a drop of nitric acid is placed on the inner sur-

face of the false angustura, it speedily produces a deep blood-red spot, which is attributable to the action of the acid on the bucine contained in the bark.—2. When a drop of nitric acid is applied to the lichens on the outer surface of the false angustura, they assume a deep emerald-green colour. Nitric acid produces no such effects on true angustura.

Aniseed.—Its taste is warm and sweet; it must be free from mustiness, and when rubbed between the hands, should exhale its peculiar aromatic odour. The small compact Spanish seed is preferable to the lighter and larger kind grown in England. The heavier the seed is, the more oil it contains.

Antimony.—It must burn before the blowpipe without giving out the odour of garlic which indicates the presence of arsenic. When strongly ignited, it must burn brilliantly and throw out sparks in every direction. Commercial antimony almost always contains arsenic which is added to it to make it crystalise with more facility and beauty. The antimony which is suspected to contain arsenic should be boiled in nitric acid until wholly converted into a white powder. The liquid should then be filtered, mixed with ammonia until it is but feebly acid, and tested with a solution of nitrate of silver and with liquid sulphuretted hydrogen. If the first test produces a yellow or red precipitate, and the last, a yellow precipitate, the antimony contains arsenic. If the white powder, on being mixed with charcoal powder and heated in a glass

tube, gives out the odour of garlic, or produces a brilliant metallic sublimate, it equally proves the presence of arsenic.—When the antimony has been dissolved in muriatic acid and precipitated by the addition of water, the filtered solution must give no blue precipitate with a solution of prussiate of potash, nor black precipitate with tincture of galls, otherwise the antimony contains iron.

When the antimony has been digested in hot nitric acid, the filtered solution must not give a white precipitate with sulphuric acid, otherwise it contains lead.

ANTIMONY, *Oxide of.*—It forms a white powder, which on being mixed with charcoal and heated in a glass tube, must give out no alliaceous odour nor any sublimate of arsenic. If it has a brown colour, and if its solution in muriatic acid has a yellowish brown colour, it contains iron, in which case the solution gives a blue precipitate when tested with a solution of prussiate of potash. It must not dissolve in nitric acid, but it must dissolve in muriatic acid without leaving a residue of silica. The solution must behave towards re-agents like a solution of pure metallic antimony. (See the foregoing article.)

ANTIMONY, *Gray Sulphuret of.*—This substance is found in the shops in fused cakes which exhibit internally a steel gray colour and a radiated or fibrous crystaline structure. It fuses with great ease before the blowpipe, burns with a bluish green flame and a sulphurous odour, and produces oxide of anti-

mony. It must not give out the odour of garlic, otherwise it contains arsenic. When dissolved in nitro-muriatic acid and precipitated by water, the filtered solution must give no yellow precipitate with liquid sulphuretted hydrogen, otherwise it contains arsenic. The precipitate which is thrown down by water must not possess a dark colour, otherwise it contains iron. The solution filtered from the precipitate produced by water must give no brown flocks when mixed with ammonia, otherwise it contains iron. When the filtered solution is slightly acidulated with sulphuric acid, it must give no red precipitate with a solution of prussiate of potash, otherwise it contains copper.—Another portion of the solution of antimony in nitro-muriatic acid is evaporated to dryness without previous precipitation by water. The mass is dissolved in a mixture of muriatic acid and alcohol. If a crystaline precipitate remains in the solution, it consists of chloride of lead.

Another portion of the sulphuret of antimony is boiled in nitro-muriatic acid, until it is entirely dissolved, or until nothing remains undissolved but a minute portion of sulphur. The solution is precipitated by water, and the precipitate is separated by filtration. The clear liquid is then exposed to a current of sulphuretted hydrogen gas. If an orange precipitate, the colour of which passes into yellow, is produced, it indicates the presence of arsenic, but does not determine it with sufficient certainty. The yellow precipitate

must therefore be re-dissolved in nitric acid, and the solution must be mixed with a solution of soda or ammonia, and tested with a solution of nitrate of silver. If this produces a red precipitate, the presence of arsenic is demonstrated.

ANTIMONY GLASS.—This is a compound of oxide of antimony with sulphuret of antimony. It forms a glassy substance of a hyacinth-red colour. It is transparent or translucent. Its fracture is conchoidal and shining. It dissolves in muriatic acid, disengaging sulphuretted hydrogen gas, and depositing a small portion of sulphur. The solution must have a pale colour, and should be tested in the same manner as the solution of antimony spoken of in the preceding article. It is particularly liable to contain iron, since the manufacturers sometimes employ spatulas of iron in its preparation. When it has been melted too strongly in the crucible, it contains silica, which remains undissolved in the muriatic acid solution.

ANTIMONY, *Golden Sulphuret of*.—It forms a fine orange powder. If it is whitish, it contains foreign substances or is partly decomposed; if brownish, it contains kermes mineral. When heated in a glass tube, it must give out water and be converted into the gray sulphuret of antimony. Before the blowpipe it must volatilise completely, giving out the odour of sulphurous acid, but not the odour of arsenic. It must have no taste, and must communicate no taste to water. Water in which it has been boiled, must give no preci-

pitate with a solution of chloride of barium, otherwise the sulphuret contains sulphate of potash, and has not been properly washed. It must dissolve completely in a solution of potash or in muriatic acid, and the acid solution must give no blue precipitate with a solution of prussiate of potash, otherwise it contains iron. Pounded brick may be detected by its not volatilising before the blowpipe. Gross adulterations like this occur but rarely.

ANTIMONY, *Red Sulphuret of. Kermes Mineral.*—It forms a brown powder. If the colour passes towards orange, the presence of golden sulphuret may be expected. If it is whitish, it contains oxide of antimony. When heated in a glass tube, it gives off water and oxide of antimony, and is converted into gray oxide of antimony. Before the blowpipe, it volatilises with the odour of sulphurous acid: it must not give out the odour of arsenic. It must have no taste, and when digested in water must not communicate to it the property of giving a white precipitate with a solution of chloride of barium, otherwise it contains sulphate of potash. It must not dissolve completely in a solution of potash, but it must dissolve in muriatic acid, and the acid solution must give no blue precipitate with a solution of prussiate of potash, otherwise it contains iron. If it leaves a coarse red powder when dissolved in muriatic acid, it contains pounded brick. It must not give off empyreumatic oil or empyreumatic water, when heated in a glass tube, otherwise it contains organic substances. If

boiled in spirits of turpentine it must not give it an orange-yellow colour, and afford crystals of sulphur on cooling, otherwise it contains golden sulphuret.

ANTIMONY, *Chloride of. Butter of Antimony.*—It forms a thick liquid like oil, which has a pale colour, and gives a white precipitate when mixed with water. The solution must be tested, by the processes detailed above, for lead, iron, arsenic, &c.

ANTIMONY *and* POTASH, *Tartrate of. Tartar Emetic.*—The impurities most frequently found in tartar emetic are tartrate of lime, tartrate of iron, tartrate of potash and supertartrate of potash. The latter is particularly liable to be contained in the tartar emetic which is manufactured according to the process recommended by Mr. Phillips.—Good tartar emetic forms extremely white tetrahedral and octahedral crystals, which on being pulverised, produce a perfectly white powder. The crystals are transparent at first, but they soon effloresce and become opaque. It is best to preserve tartar emetic in the state of powder, to prevent the loss of weight from the escape of water of crystalisation, and to insure uniformity of strength in the doses.

Tartar emetic must dissolve without residue in fifteen parts of cold water. Or if heat is applied to facilitate the solution, the dissolved salt must not crystalise in needles as the liquor cools, otherwise it contains tartrate of lime.

If any insoluble matter remains when fifteen parts of water are employed, it consists of

supertartrate of potash. This is identified as such by giving no yellow precipitate, when dissolved by itself in water, and tested with liquid sulphuretted hydrogen. The following is another test for the detection of supertartrate of potash in tartar emetic. Dissolve the suspected tartar emetic in four times its weight of water and add to the solution the test described below. If a precipitate appears either immediately or after a few minutes' delay, it indicates the presence of supertartrate of potash. This test is very delicate.

Preparation of the Test. Take eight parts of crystalised acetate of lead and thirty-two parts of water. Dissolve the salt in the water at a boiling temperature. Replace the water which evaporates, and separate the insoluble carbonate of lead by filtration. Add to the solution three-eighths of its bulk of acetic acid.

The clear solution of tartar emetic in water must be perfectly colourless and exhibit no tint of yellow, otherwise it contains iron. When concentrated by evaporation and set by to crystalise, it must produce tetrahedrons and octahedrons and never needle-formed crystals, otherwise it contains lime. When the solution is mixed with a solution of prussiate of potash, it must give no blue precipitate, otherwise it contains iron. It must give no white precipitate with a solution of nitrate of silver, or the precipitate must be soluble in nitric acid, otherwise it contains muriatic acid. It must give with a solution of chloride of barium, no precipitate which cannot be dissolved by ni-

tric acid, otherwise it contains sulphuric acid. When tested with liquid sulphuretted hydrogen or hydrosulphuret of ammonia, it must give a pure orange-coloured and never any black precipitate. When tartar emetic dissolves in less than fifteen parts of water, it contains neutral tartrate of potash.

ANTIMONIAL WINE.—It should be recently prepared, because all solutions of tartar emetic are very liable to undergo spontaneous decomposition. It ought to be clear and without deposit. If it has experienced decomposition, it will contain no antimony, the absence of which may be proved by the process described at p. 14.

ARROW-ROOT.—This substance is white, tasteless, and soft to the touch; it has the appearance of extremely fine grains. It is frequently adulterated with *wheat starch* and *potatoe starch*.

Discrimination. Arrow-root is not so white as the two other kinds of starch, but its grains are much finer, and when examined by a magnifying glass, appear pearly and very brilliant. Moreover, true arrow-root always contains a great number of little clots, which are formed by the aggregation of the minuter grains of arrow-root during the operation of drying. These clots crumble with ease when bruised with the fingers. Finally, the jelly which arrow-root produces with water has no odour, while the jellies which are formed by starch and potatoe-starch are characterised by an odour at once powerful and peculiar.

Arsenic, *White Oxide of*.—It is liable to be mixed with chalk and sulphate of lime. If the suspected arsenic is heated in an iron spoon, it ought to volatilise without residue. If it contains chalk and sulphate of lime, they remain behind. Adulterated arsenic can never be employed in medicine without great danger. Its preparations ought always to be equally pure and of the same degree of strength.

Assafœtida.—The best kind is imported in boxes or casks; it is found in commerce in large lumps, composed of irregular agglutinated masses which have a tough consistence, and a very mottled appearance, in consequence of the presence of drops or tears of a white, violet, red, and brown tint, all mixed together. An inferior kind sometimes met with is full of sand, and smells very fetid; it is said to be composed of garlic, sagapenum, turpentine, and a small proportion of real assafœtida. This kind is very brittle and gives a large residue when treated with spirits of wine, whereas good assafœtida leaves but the fifth part of its weight of insoluble residue.

Balsam of Copaiba.—If it does not dissolve in a mixture of four parts of alcohol and one of rectified ether, it is impure. Sometimes it contains rape oil, in which case, the drops which are suffered to fall into water, soon lose their spherical form.

Balsam of Peru.—It has a deep, brownish red colour, a sirupy consistence, a strong and agreeable, though rather empyreumatic odour, and a pungent, acrid and bitter taste. It

should dissolve in rectified alcohol, and leave a very slight pulverulent residue. It is sometimes adulterated with fixed oil, and sometimes with alcohol. The presence of the latter may be detected by the process given under the article, *"Volatile Oils."*

Barium, *Chloride of.*—It crystalises in perfectly white tables, which dissolve completely in six parts of water. The solution, which is colourless, must give no precipitate with caustic ammonia, otherwise it contains alumina or iron. The ammonia must be free from carbonate of ammonia, and a judgment must be formed the instant after adding the test, because the alcaline mixture soon acquires carbonic acid from the atmosphere and then carbonate of barytes precipitates. The crystals must not give a red flame when heated before the blowpipe, otherwise they contain lime or strontian; nor must they become moist in the air, otherwise they contain chloride of calcium. When the solution is tested with hydrosulphuret of ammonia, it must give no black precipitate, otherwise it contains iron, nor a white one, otherwise it contains alumina.

Beer.—By the term *beer* I understand a liquor brewed from malt and hops. Ale of all kinds, London porter, and brown stout are varieties of beer. The liquor usually sold under one or other of the above names, is said to be occasionally adulterated with the following ingredients:—

I. *Vegetable and Animal Adulterants.*

1. Coculus indicus.
2. Opium.
3. Extract of poppies.
4. St. Ignatius's bean.
5. Nux vomica.
6. Tobacco.
7. Bohemian rosemary.
8. Henbane.

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9. Aloes.
10. Quassia wood.
11. Extract of gentian.
12. Sweet-scented flag.
13. Wormwood.
14. Horehound.
15. Bitter oranges.

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16. Spanish liquorice.
17. Molasses (treacle).
18. Honey.
19. Mucilage of flax-seed.

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20. Burnt flour.
21. Burnt sugar.
22. Burnt treacle.
23. Burnt malt.

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24. Capsicum.
25. Ginger.
26. Cassia-buds.
27. Grains of Paradise.
28. Coriander seeds.
29. Orange peels.
30. Caraway seeds.

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31. Isinglass.
32. White of eggs.
33. Hartshorn.
34. Preparations of fish.

II. *Mineral Adulterants.*

35. Sulphuric acid.
36. Sulphate of iron.
37. Alum, or sulphate of alumina and potash.
38. Gypsum, or sulphate of lime.
39. Oyster shells.
40. Egg shells.
41. Crab's claws.
42. Marble } Carbonate of lime.
43. Chalk } Carbonate of lime.
44. Carbonate of potash.
45. Carbonate of soda.
46. Common salt.

III. *Liquid Multipliers of Beer.*

47. Water.
48. Small beer.

Origin of the Introduction of the above Substances into Beer.—Some of these adulterants

are employed by the brewer, and others by the publican; or in other words, some of them are used in the *brewing* of beer, and others are *added* to the beer after it is brewed. The object of the brewer is to save malt and hops; the object of the publican is to multiply or increase the quantity of his beer. The liquor produced by the doctoring brewer is a spurious imitation of beer, that produced by the doctoring publican is a mixture of good beer with coloured water. Either of these liquors is wholesome, dangerous, or poisonous, according to the proportion which its noxious ingredients bear to its malt, hops, and water.

The Art of Doctoring diseased Beer.—When the brewer makes a large quantity of beer from a small quantity of malt and hops, or when the publican mixes his strong beer with water or small beer, the product is always in a state of disease; that is to say, the resulting beer is so weak and vapid, that no mortal man can be induced to pour it down his throat. But as beer of this sort is always made *to sell,* and as nobody will buy it while it is in a state of *evident* disease, the ingenuity of the beer-doctor is taxed to supply the means of giving a *healthy* APPEARANCE to the liquor which is afflicted with the most incurable disorders. It is not desired either by the brewer or publican that the diseased beer should be rendered *absolutely good;* it is quite sufficient for their purposes that it should be made to *appear* good. All that they insist upon is that the beer shall be put into a *sale-*

able state; they do not trouble themselves with reflections about its *wholesomeness* or *unwholesomeness* nor indeed, is there any reason why they should; for it is very evident that reflections of that sort ought to be made by the individuals who have the *drinking* of the beer, and not by those who have merely the *selling* of it.

The diseases of beer and their favourite remedies are as follow:—

Remedies for want of Alcohol.—All beer which has been made from malt, contains a certain quantity of pure spirit, to the presence of which its exhilarating and intoxicating qualities are attributable. Good London porter contains about four *per cent.* of alcohol; that is to say, twenty-five pints of porter contain one pint of pure spirit. Other sorts of malt liquor contain different quantities of alcohol. Brown stout contains from five to six and a half *per cent.*; Edinburgh ale six *per cent.*; Burton ale from six to eight *per cent.*; and small beer from three-fourths to one-fourth *per cent.* When beer is deficient in malt, it is deficient in alcohol, and consequently deficient in strength. When the deficiency is large, it can be detected by the taste, which is then termed *weak.* This is a disease which the beer-doctors attempt to cure by the introduction of certain substances which, though free from alcohol, possess the property of *stupifying* or *intoxicating* the persons who swallow them. These substances are those marked No. 1 to 8, in the above

list of adulterants. The objection to the use of these substances, is simply this, that they are *all poisonous*. This, to be sure, is a trifling consideration for the *beer-doctor*, but it is of pretty considerable importance to the *beer drinker*, on which account I shall briefly state the peculiar properties of these adulterants.

Coculus Indicus—Has the appearance of a large rough black pea, the ligneous pericarp of which encloses a pale grayish-yellow, brittle kernel of a very strong and permanently bitter taste, by which property it is qualified to *save hops as well as malt* in the brewing of beer. It is a familiar poison for destroying fish. By chemical analysis, it yields a fifth part of its weight of picrotoxa, a crystaline substance of which ten grains are sufficient to kill a dog in twenty-five minutes. —*Opium*. When this drug is taken in small quantities, it is highly stimulating. A gentleman who took its compounds frequently, has stated that if in the evening when he felt sleepy he took thirty drops of laudanum, he was so much enlivened that he could resume his studies: and if, when the usual subsequent drowsiness approached, which it did in two hours, he took a hundred drops more, he soon became so much exhilarated that he was compelled to laugh and sing and dance. After a short time, the customary stupor succeeded. In large doses, opium causes death. The symptoms of poisoning by opium are giddiness, stupor, insensibility, slow breathing, ghastly appearance, death. It has a strong

and peculiar taste, so that no one would think it easy to administer opium secretly. The plan resorted to by thieves and others, seems to be to deaden the sense of taste by strong spirits, and then to ply their victim with porter or ale drugged with some of the compounds of opium. Laudanum, the extract of poppies, the black drop, and Battley's sedative liquor possess the same properties as opium.—*St. Ignatius's Bean.* This contains nearly 18 parts in 1000 of strychnia, the most deadly of all known poisons, excepting prussic acid. This strychnia is the poison contained in the *upas tieuté* or celebrated poison-tree of Java. Criminals in that country were formerly executed by darts poisoned with this substance. Dr. Darwin relates that upon being wounded they trembled violently, uttered piercing cries and perished in frightful convulsions in ten or fifteen minutes. A man who had taken *half* a bean, narrowly escaped death.—*Nux Vomica.* This substance contains a large quantity of strychnia, the alcaline substance which forms the poisonous ingredient in the upas tree and St. Ignatius's bean. Strychnia is so intensely bitter that one grain of it dissolved in eighty pounds of water, produces a bitter solution. Dr. Christison gives the following account of its action on animals. "I have killed a dog in two minutes with the sixth part of a grain of strychnia injected into the chest, and I have seen a wild-boar killed in the same manner in ten minutes, by the third of a grain. There

is little doubt that half a grain thrust into a wound would kill a man in less than a quarter of an hour. The symptoms produced are very uniform and striking. The animal becomes agitated and trembles, and is then seized with stiffness and starting of the limbs. These symptoms increase till at length it is attacked with a fit of violent general spasm, in which the head is bent back, the spine stiffened, the limbs extended and rigid, and the respiration checked by the fixing of the chest. The fit is then succeeded by an interval of calm, during which the senses are quite entire. But another paroxysm soon sets in, and then another and another, till at length a fit takes place more violent than any before it, and the animal perishes suffocated. The poisonous properties of nux vomica are now very well known to the vulgar; and in consequence it has been sometimes chosen for the instrument of voluntary death, although no poison causes such torture. It is difficult to conceive, on account of its intensely bitter taste, how any one could make it the instrument of murder. But a fact is stated in a late number of 'Rust's Journal,' which shows that it may be used for that purpose. At a drinking party one man wagered with another, that if he took a little *coculus indicus* in beer, he would be compelled to walk home on his head. The wager was taken and the potion drunk; but nux vomica was substituted for the coculus indicus, itself too a virulent poison; and the man went home and

died in convulsions fifteen minutes afterwards.—A young woman, in a fit of melancholy, took two or three drachms of powdered nux vomica in water. She was attacked in half an hour with slight convulsions, succeeded by much agitation and anxiety. In a few minutes she had another, and not long afterwards a third, each about two minutes in duration. During these fits, the whole body was stiffened and straightened, the legs pushed out, and forced wide apart; no pulse or breathing could be perceived; the face and hands were livid, and the muscles of the former violently convulsed. In the short intervals between the fits she was quite sensible, had a quick faint pulse, complained of sickness with great thirst, and perspired freely. A fourth and most violent fit soon succeeded, in which the whole body was extended to the utmost from head to foot. From this she never recovered: she seemed to fall into a state of asphyxia, relaxed her grasp, and dropped her hands on her knees. Her brows, however, remained contracted, her lips drawn apart, salivary foam issued from the corners of the mouth, and the expression of the countenance was altogether most horrific. She died an hour after swallowing the poison." It has been ascertained that small doses of this noxious drug cause death as *certainly* though more slowly than large doses. It is therefore capable of being employed as a very formidable secret poison, and its use as an adulterant of beer is in the highest possible degree danger-

ous and criminal.—*Tobacco.* The poisonous effects of this plant are frequently witnessed in young men while making their first efforts to acquire the vulgar and absurd practice of smoking. The symptoms are acceleration of the pulse, transient excitement, sudden giddiness, fainting, great sickness, accompanied by a weak quivering pulse, and some degree of somnolency is not uncommon. A young man who smoked two pipes for his first debauch, was seized with nausea, vomiting, fainting, then stupor, stertorous breathing, general spasms, and insensible pupil. This continued for two days, after which he recovered. A man was killed by smoking seventeen pipes of tobacco at a sitting, and another by smoking eighteen pipes. Many accidents have been occasioned by the application of tobacco to external sores and by employing it in injections; and Orfila states that Santeuil was poisoned by tobacco mixed with his wine.—*Bohemian Rosemary* is said to produce a quick and raving intoxication, or temporary madness.—*Henbane.* In small doses, the preparations of this plant generally induce pleasant sleep, but in some subjects occasion headache, delirium, nausea, vomiting and feverishness.—Two soldiers who ate large quantities of the young shoots dressed with olive oil, became giddy and stupid, lost their speech, and had a dull haggard look; the eyes were excessively dilated but insensible, the pulse small, the breathing difficult, the jaw locked and the mouth distorted by a sardonic

laugh. Though sensibility was extinct and the limbs cold and palsied, vomiting was induced by emetics. The delirium became extravagant as the somnolency abated; but in two days the men were cured.—A family of six persons were poisoned at dinner by eating the roots of henbane in mistake for parsnips. Several became delirious and danced about the room like maniacs; one appeared as if he had got drunk, and a woman became profoundly and irrecoverably sleepy. Emetics could not be introduced into the stomach, stimulant clysters had no effect, external stimuli of every kind failed to rouse her, and she expired early on the ensuing morning.

Such are the properties of a few of the substances which are employed in the adulteration of beer.

Remedies for want of Sugar. To supply a deficiency of saccharine matter which is characteristic of beer that has either been brewed from too small a quantity of malt or has subsequently been mixed with a considerable proportion of water, it is customary with the beer-doctors to add the substances marked in the table of adulterants with the Nos. 16 to 19. None of these remedies possess poisonous properties, which is a circumstance highly in favour of the beer-drinker. Heavy penalties, however, are inflicted by the legislature on all persons known to make use of these drugs.

Remedies for want of Colour. Porter is distinguished from other sorts of beer, by

various qualities, and particularly by a brownness of colour and by a peculiar burnt or empyreumatic taste. These were produced originally by brewing it from brown malt instead of from pale malt. But as a larger quantity of wort of a given strength can be produced from pale malt than from brown, the former was first partially and then entirely substituted for the latter. But as this change produced porter which was deficient both in colour and flavour, extraneous substances were employed to remedy the diseases induced in the porter by this close attention to economy. The substances thus employed were those marked in the table from No. 20 to 23. The whole of these except the last are prohibited by acts of parliament; but they have nevertheless been long and very generally employed in spite of such prohibition. None of these colouring matters are, perhaps, injurious to health; but it has been stated that porter which has been coloured by burnt (or patent) malt is very liable to spoil, on account of the fermentation produced by the gum-like matter of which the patent malt is constituted. Where good brown malt is employed in brewing, colouring matter of any kind is unnecessary; but where colouring matter is necessary to be added, burnt sugar is probably the best substance which can be employed. The addition of sugar to beer is, however, liable to punishment.

Remedies for want of Bitterness.—Wort of malt is boiled with hops, partly that it may

acquire a peculiar aromatic flavour which is proper to hops, partly that the bitterness of the hops may cover the sweetness of the undecomposed saccharine matter in the beer, and partly that the gallic acid and tannin contained in the hops may deprive the beer by precipitation, of a peculiar vegetable mucilage which it retains in suspension. The consequences of the want of a sufficient proportion of hops are, that the beer is destitute of the bitter and aromatic taste of the hop, and is liable to go into the acetous fermentation in consequence of retaining too great a quantity of mucilage in suspension. As the want of a due proportion of hops in beer is liable to immediate detection by the taste, the beer-doctor remedies this disease by adding to the beer a variety of substances which possess at least the bitterness of the hop, if not its other good qualities. These substances are marked in the table of adulterants by Nos. 9 to 16. None of these substances singly, nor any number of them combined, is capable of furnishing a substitute for hops. The beer produced by means of them is in all cases, not only faulty in respect to taste, but incomparably less fit for keeping or for exportation.

Remedies for want of Pungency.—Good beer possesses a peculiar pungency, which is partly owing to the presence of free carbonic acid, and partly to the existence of other compounds formed by the decomposition of the malt and hops. This pungency or freshness

of taste is particularly *observable* in beer just drawn from the butt, or newly unbottled. The want of this pungency in weak, watery, insipid beer, is a disease which the doctors try to remedy by the addition of various compounds possessed of a permanently hot, acrid or aromatic flavour. These substances constitute Nos. 24 to 30 in the foregoing table of adulterants. Concentrated tinctures of capsicum and grains of Paradise are standing articles in the price-currents of brewers' druggists. Ginger-root, orange peels, and coriander seeds are chiefly employed by ale brewers. I am not aware that any of these substances are gifted with poisonous properties, or are injurious to health when administered in small quantities.

Remedies for Muddiness.—When the wort of malt has not been boiled with a proper proportion of hops, when the brewing has been mismanaged, and in a great variety of other circumstances, a sort of beer is produced which, instead of being bright and transparent, is muddy and opaque. This muddiness of beer is a disease which the doctors remedy by an operation termed *fining*. The extraneous substances employed in fining are those which constitute Nos. 31 to 34 in the table of adulterants; the action of these substances being, in cases of obstinacy, assisted by a small dose of oil of vitriol. The transparency produced by fining beer with white of eggs and other preparations of a similar description, is in general only temporary; the

fined beer very soon becomes ropy and needs to be doctored afresh.

Having explained the use and abuse of the vegetable and animal adulterants of beer, I now pass to the consideration of the mineral adulterants.

Remedy for want of Age.—New beer, particularly that which contains a good supply of hops, is possessed of a peculiar aromatic bitterness; and while in this state, it is usually termed *mild beer*. In proportion as the beer increases in age, it gradually loses its excess of bitterness, and finally becomes acid or sour, in which state it is termed *stale beer*. The acidulation is attributable to the gradual and spontaneous formation of the acetic and malic acids in the beer. As some persons prefer mild and others stale beer, it is customary with publicans to keep the two sorts in stock, and by their admixture, in various proportions, to attempt the gratification of the diversified tastes of their different customers. This is perfectly right and proper. But as the laying by of beer in stock for a year or two to get stale, infers the laying out of capital, it leads the publican to the conviction that stale beer costs him a little more money than new beer. The consequence of this is, that he attempts to make his customers drink *new* beer while he persuades them that they are drinking *stale* beer. This hocus pocus of the beer-doctor is performed by giving to new beer the acidity which is the chief character-

istic of old beer. It is the easiest thing in the world to manage this cheat; for the conjuror has nothing more to do than to mix with the new beer a very small portion of sulphuric acid. This liquid effects as great a change of taste in beer in five minutes, as time is capable of effecting in five years.

Remedy for want of Astringency.—When strong beer has been diluted with water or small beer, or when beer has been brewed from an insufficient quantity of malt and hops, it is weak, flat, and insipid, and destitute of that strength, fullness, and roughness of taste which characterises genuine strong beer. The disease of insipidity is that which attacks strong beer most frequently; because, of all the substances which are employed in the adulteration of this beverage, none are added to it, either *generally* or in such *large doses,* as water and small beer; and these liquids reduce the strength of the beer exactly in the ratio of the dilution. Hence it is of the greatest importance to the knavish publican, to be able to doctor the beer for insipidity, in such a manner as to screen it at least from immediate discovery. The remedy consists, partly in the addition of the hot, pungent, bitter, and stupifying drugs, described in the preceding paragraphs, and partly in the addition of a solution of the ferruginous salt called green vitriol or sulphate of iron. The powerful styptic taste of this substance is well adapted to give an artificial astringency to weak and watery

beer. The employment of green vitriol as an adulterant of beer is therefore carried to an amazing extent. Several convictions for the offence have taken place within the last few months; and but a short time ago, its use might almost be said to be general. It is very likely, however, to be diminished in future, because the former difficulty of detecting it no longer exists, and the test for its presence which is given in this work, is one which can readily be made use of, by operators the most unskilful.

Remedy for Old Age.—As the ingenuity of the beer-doctors has detected a method of converting *new* beer into *old*, so also, has it discovered the means of converting *old* beer into *new*. Nobody will deny the particular conveniency of these double practices. By means of the beer-doctor's remedies, a publican is enabled with a single sort of beer to gratify the tastes of all his customers, however numerous or capricious or dissimilar they may be. As new beer is converted into old, by the addition of acids, so *inversely*, old beer is converted into new, by the addition of substances which have the power of neutralising acids. The substances employed for this purpose are the alcalies, lime, potash and soda, and these are taken for use in the state described in the table of adulterants, Nos. 39 to 45. The five compounds from Nos. 39 to 43, all contain lime for their base. The substances No. 39 to 41 contain both the phosphoric and carbonic acids united to the lime, and being of a

very compact texture, are incapable of acting on the acetic and malic acids of the stale beer with any considerable degree of energy. But the compounds, Nos. 42 to 45, which contain carbonic acid alone, are readily decomposable by the acids of the beer, which combine and form peculiar compounds with the lime, potash, or soda, and set the carbonic acid at liberty. Thus, with the same facility that new beer is converted into old, can old beer be converted into new; and the operations of time, both prospective and retrospective, are set at naught by the accomplished chemists who act the wonder-working part of doctors of beer. But the mildness of stale beer, like the staleness of mild beer, is not without its disadvantages. The beer which has been rendered palatable by the addition of alcalies, is unfortunately very liable to spoil. It soon loses its vinous taste—becomes vapid—assumes a muddy-gray colour—and then a taste so exceedingly disagreeable and so uncommonly obstinate, that the utmost art of the doctor is fairly unable to put the beer into a condition fit to be converted into money.

When a barrel of home-brewed accidentally turns sour, it can be rendered drinkable by the addition of a very small quantity of pounded carbonate of soda. The drug should not be added to the beer in the barrel, but only to a glass or a jugful at a time. This is a species of adulteration which many families may be inclined to resort to, after their ale-cellars have been visited by a sub-division of

a thunder-storm. If a pinch of the carbonate of soda is thrown into a glass of sour ale, the beverage effervesces and acquires an agreeable pungency from the presence of carbonic acid, while at the same time, it is rendered mild by the saturation of its excess of native acid. The acetate and malate of soda produced in the beer by the expedient just described, are in no greater degree injurious to the health, than are the citrate and tartrate of soda produced in the composition of ginger beer or soda water.

Remedy for Want of Froth.—The people of London have a peculiar prejudice in favour of froth. They will drink no beer which does not possess the grand requisite of a *cauliflower head.* The publican is of course perfectly aware of the existence of this prejudice, and therefore never fails

"Whether his porter will let him or no"—

To give to his pots of porter the admired and desired pyramid of froth. This is effected by the addition of a substance technically termed *beer heading,* the component parts of which are the three compounds numbered 36, 37 and 46 in the table of adulterants; these substances are green vitriol, alum and common salt. The necessity of adding this compound to produce a cauliflower head is owing to the adulteration of the porter with water or small beer; for good porter possesses the property of bearing a strong white froth without any such addition. The beer heading produces a large body of froth only in beer

to which the previous addition of treacle has communicated a certain degree of spissitude. Though good porter certainly froths well, yet the presence of a frothy head is *no proof* of the presence of good porter. The people of London too often overlook this consideration, in their unbounded love of the cauliflower head.

For the convenience of the brewers and publicans who are addicted to doctoring of beer, a variety of the drugs alluded to in the preceding pages are made up into compound mixtures and sold in a state fit for immediate use. This is done to render the employment of them less liable to detection. Some of these compounds bear the following names. *Multum.* Extract of quassia and liquorice. *Hard multum,* or *black extract.* Extract of the poisonous berry named coculus indicus. *Bittern.* Extract of coculus indicus with extract of quassia, Spanish liquorice and calcined sulphate of iron. *Bitter balls.* Powder of gentian root, two parts, extract of gentian one part, treacle in sufficient quantity to form the mass into balls. *Essentia bina,* or colouring. Sugar boiled down till it has acquired a black colour and an empyreumatic flavour. *Beer heading.* Sulphate of iron, alum and salt.

Instructions for the Detection of Adulterants in Beer.—The presence of ORGANIC *adulterants* in beer is in most cases incapable of chemical demonstration. There are no tests in present use by which the sugar of liquorice or of molasses, can be distinguished from the

sugar of malt; nor any means of discriminating the mucilage of flax seed from the mucilage which is proper to genuine malt liquor. It is indeed sometimes possible to distinguish the bitterness of quassia from that which is the characteristic of hops; and when opium and nux vomica are present in considerable quantity, they may be distinctly detected by carefully-conducted chemical experiments. But, speaking in a general manner, and with relation to the chemical acquirements and experimental skill of the persons to whom a popular treatise of this sort is supposed to be addressed, it must be asserted that the substances which fall between Nos. 1 and 34, in the Table of Adulterants at p. 96, are altogether incapable of detection by the addition of any known chemical tests to the adulterated beer. The taste and appearance of the beer, and still more the effects it produces when taken into the stomach, are the best data we have on which to ground a judgment respecting its purity or impurity. All chemical tests for the detection of organic substances in beer, are liable to so much ambiguity that I refrain from describing them, fearing rather to mislead the reader than to serve him. There is only one chemical test which can be said to be free from ambiguity. This relates to the absolute strength of the beer, and consists in determining the proportion of alcohol which it may contain. I shall speak of this operation in the article on wine. It is possible to determine, from the *per centage* of alcohol, whether the *apparent strength* of a given sample

of beer is due to the presence of pure malt spirit, or to the admixture of pungent and intoxicating drugs. As for the detection of nux vomica and other adulterants, when present in poisonous doses, I shall content myself with requesting the reader to seek for processes in the "*Treatise on Poisons,*" which has been published by Dr. CHRISTISON. It is desirable that the EXCISE, or the great London brewers (who are said to be free from the sin of doctoring) would PAY *some respectable chemist to make a series of experiments respecting the best means of detecting the presence of organic adulterants in beer.* The subject is one of great public importance; yet for all that, no chemist whose time is of any value, will ever undertake the inquiry unless he is hired to do so; for as it would be necessary to brew spurious beer and to manufacture adulterated beer, and then to examine the behaviour of these liquors towards a great variety of chemical tests, the experiments would occupy so much time, and be attended with so much expense, that no person is ever likely to make them for his *individual* gratification. Nothing will tend to prevent the adulteration of beer, except the consciousness of being exposed to detection. So long as the public are destitute of the means of detecting organic adulterants, such substances will be employed to the greatest possible extent by all the brewers and publicans by whom adulteration is practised; while in proportion as chemical tests for the detection of organic bodies

are made known, in the same proportion will the employment of such substances decline. The fulminations of the legislature are here of small avail; for acts of parliament have but little power in comparison with chemical tests. It is to the operations of the laboratory and not to the proceedings in St. Stephen's Chapel, that the public must look for protection against beer-doctors. I call upon all beer-drinkers to think on this. Let them pay somebody to teach them how wholesome beer is to be distinguished from such as is unwholesome. They will then find that the practice of adulterating beer will diminish, and that cases of tun-bellies, apoplexy and sudden death will become much rarer.

Though we cannot at present detect with certainty the presence of vegetable adulterants in beer, this is far from being the case with respect to mineral adulterants: for on the contrary, the substances contained in the Table at p. 96, from Nos. 35 to 46 are all capable of being distinctly detected, even when present in extremely small proportions.

Detection of Iron in Beer.—Of all the substances mentioned in the table referred to, that which it is of the most importance to detect is the *sulphate of iron;* an easy and effectual process for the detection of which has been given at p. 41.

Detection of Sulphuric Acid in Beer.—This acid forms a component part of the adulterants Nos. 35 to 38. It can be easily detected by

means of a solution of chloride of barium. (See p. 53.)

Detection of Lime in Beer.—Lime is a constituent of the adulterants Nos. 38 to 43. When any of these compounds are employed to correct the acidity of stale beer, a portion of lime remains dissolved in the beer, in the state of acetate of lime. It can be detected by the processes described (p. 45). Egg-shells and crabs'-claws contain phosphate of lime, the presence of which can be detected by a process which will be found under the head of "Bread," where the method of detecting bone-ashes in organic mixtures is described.

Detection of Potash in Beer.—This alcali forms part of the potashes or pearlashes employed to correct the acidity of stale beer, as well as of the alum, which enters into the composition of heading-stuff. I have shown (p. 50), in what manner it may be detected.

Detection of Soda in Beer.—Carbonate of soda added to correct acidity, and common salt, added in the state of heading-stuff, both communicate soda to beer. Its presence may be detected by the process described (p. 51).

Detection of Alumina in Beer.—This earth is a constituent of alum. It can be detected by the processes given (p. 49), and again under the head of "Bread."

Detection of Chlorine or Muriatic Acid in Beer.—Chlorine finds its way into beer as a constituent of common salt. The method of detecting it has been described (p. 58).

Detection of Water in Beer.—When strong

beer is found to contain *iron,* the inference to be drawn is, that it has previously been diluted with water or small beer; because the introduction of iron is due to the necessity of giving a factitious astringency to a beer which has been rendered vapid by dilution with water.

Benzoic Acid.—When benzoic acid is pure, it forms soft, colourless, feathery crystals. It generally has a slight empyreumatic odour, but ought to be inodorous. The crystals should dissolve without residuum in alcohol, and when subjected to heat, ought to fuse rapidly and crystalise into needles when cooled; heated strongly, it should volatilise without residue. If any non-volatile substance remains, the acid is impure. If charcoal remains, the acid contains resin, but charcoal is produced by the decomposition of the acid, if it is suffered to burn during its sublimation. Its solution in water must give no precipitate with a solution of chloride of barium, otherwise it contains sulphuric acid, nor with a solution of oxalate of potash, otherwise it contains lime.

Benzoin.—This is brought to market in large masses of an amygdaloidal or motley appearance; its colour is pale brown with white spots. It is brittle, has a resinous aspect and fracture, and becomes very fragrant when warmed. An article is sometimes met with, which is indistinctly mottled, has a dark colour and abounds in impurities: it is good for nothing.

Bismuth.—It dissolves completely in nitric

acid and produces a colourless solution, which, if not contaminated by an excess of acid, gives an abundant white precipitate when mixed with water. The filtered solution must give no white precipitate with sulphuric acid, otherwise it contains lead; nor must it be rendered red by a solution of prussiate of potash, otherwise it contains copper; nor blue, otherwise it contains iron.

Bismuth, *Subnitrate of. Pearl White.*—It should be an extremely white and light powder. When heated it should become yellow, and retain a lemon-yellow colour after becoming cold. It must dissolve entirely and without the least effervescence in diluted nitric acid, otherwise it contains carbonate of bismuth. The clear solution must give no precipitate with diluted sulphuric acid, otherwise it contains lead. When this preparation is free from carbonate of bismuth, it is not likely to contain iron or copper; but when these metals are present, they may be detected by the process given under the head of "Bismuth."

Bleaching Liquors.—The chlorides of potash and of soda in solution, which are now commonly sold as bleaching agents and disinfectants, are tested as to their bleaching power by the method alluded to in the following article.

Bleaching Powder. *Chloride of Lime.*—The goodness of bleaching powder is estimated by the bleaching power of the liquid produced by its solution in water. A blue liquor is prepared by dissolving indigo in

concentrated sulphuric acid and diluting the solution with 1000 parts of water. The chloride of lime to be estimated is weighed and mixed with water. A given quantity of the clear solution which it produces, is mixed with as much of the blue liquor as it can deprive of colour. The value of a given quantity of the blue liquor is previously determined by an experiment made with a sample of chloride of lime of a known good quality, and all subsequent experiments are compared with this standard. I decline to go into particulars regarding this operation, because it would carry me too far into quantitative analysis. The impurities in bleaching powder are carbonate of lime, hydrate of lime, water, straws, sand, &c.

Boracic Acid.—It must be in small, white, pearly scales, dry and soft, feebly acid, and soluble in thirty times its weight of water. The solution must give no precipitate with solutions of chloride of barium or nitrate of lead, otherwise it contains sulphuric acid, or sulphate of soda; nor with solution of nitrate of silver, otherwise it contains muriatic acid. The dry salt, when fused at the point of the blowpipe flame, should produce a green and not a yellow flame, otherwise it contains soda. This is a sharp test of its purity. To obtain very pure boracic acid for chemical purposes, the acid must be heated to redness to expel the sulphuric acid, and dissolved in pure alcohol to separate the remaining sulphate of soda, which is insoluble in that liquid.

Brandy.—Genuine brandy is the result of the distillation of wine, but an imitation of it is produced by the distillation of various other fermented liquors. We find both in the French and English markets a considerable quantity of malt brandy, of brandy from potatoes, and numerous other varieties. Chemically considered, these liquids consist of alcohol diluted with certain proportions of water, and mixed with peculiar matters, which give to each variety the taste and odour by which it is characterised.

Genuine brandy is a liquid possessing an amber colour derived from the wood of the vessels in which it is preserved. It has a warm but agreeable taste, which is considerably modified by time. All wines are capable of furnishing brandy in a certain proportion; but the brandy which is produced from the wines of Languedoc, la Saintonge and l'Angoumois, is that which is held in most esteem.

The Parisian retailers of brandy manufacture a liquor for cheap sale by the process which follows:—They dilute strong alcohol with water till the mixture possesses the specific gravity of genuine brandy, and then add a sufficient proportion of burnt sugar or of gall-nut to give the whole a proper colour and flavour. In physical characters this liquor is the same as good brandy; but it is very far from having the same flavour and good properties, and a connoisseur is not long in distinguishing the genuine liquor from the factitious.

The London spirit-sellers are little behind their brethren of Paris in ingenuity of sophistication. It is common with them to create Cognac brandy by adding burnt sugar to common malt spirit.

It is customary with some spirit-merchants to communicate to brandy a hot and piquant taste by the addition of various aromatic substances, such as pepper, ginger, capsicum, &c. This species of fraud is detected by the persisting acritude of the adulterated liquors. When the presence of aromatics is suspected in brandy, the liquid should be slowly evaporated till reduced to a third of its volume; the alcohol is thus expelled and the residual aqueous liquor, which often becomes troubled and milky, preserves its acrid and burning taste, which under these circumstances is readily distinguished from that of brandy.

When alcohol is diluted with water till it reaches the specific gravity of brandy, it invariably assumes a milky appearance, and does not resume its perfect transparency until after a very considerable period. The milkiness proceeds from the separation of a certain quantity of volatile oil, which is found to exist in all kinds of alcohol, and which is partially precipitated when the menstruum is weakened in its solvent power by the addition of water.

The clarification of diluted spirits is facilitated by some merchants by the addition of a small quantity of a solution of sugar of lead: this substance, with the help of a good stirring, and a subsequent repose, restores to the liquid

its wished-for transparency. The first effect of the sugar of lead is to increase the opacity of the mixture, but after a repose of twenty-four hours, the whole liquid becomes perfectly limpid.

Ought not this reprehensible practice to be repressed by the correctional hand of authority? It is in vain to object that the proportion of the lead in relation to the quantity of the liquid is too small to produce any serious accident. The public ought to be of a contrary opinion, since facts have proved most decidedly that a proportion of sugar of lead, so small as to be scarcely sensible to the power of re-agents, is capable of acting in a most injurious manner when taken into the human frame with regularity and for a long period.

It is fortunate that the presence of lead cannot escape detection, if the liquid which contains it is made the subject of experiment by the chemist. The details at pages 8 and 12 are sufficient to show in what manner the very smallest proportion of this deadly metal may be rendered evident to the senses.—The presence of *copper* in brandy may be detected by the processes described at pages 2 and 4.

The adulteration of brandy with British molasses or sugar spirit, may in some cases be detected from the peculiar odour which is exhaled when the adulterated liquor is rubbed between the palms of the hands. It may also be discovered by burning a portion of the suspected brandy in a spoon over a

candle till the liquor ceases to be inflammable. The residual liquor, if left by genuine brandy, possesses a vinous odour resembling genuine brandy; but if left by adulterated brandy, it possesses a peculiarly disagreeable smell, resembling that of empyreumatic gin.

It is stated by some writers, that English brandy consists of malt spirit, flavoured with sweet spirit of nitre, and coloured with terra Japonica.

Bread.—The principal substances alleged to have been employed by various bakers in the adulteration of bread, are the following:—Gypsum or plaster of Paris, chalk, Cornish pipe-clay, bean flour, peas-meal, potatoes, bone-ashes, alum, carbonate of ammonia, and blue vitriol.

Good bread is white in colour and porous and spongy in texture. Everywhere in the country the quality of bread is judged of from the taste, smell and texture; but the London people will eat no bread which does not possess a certain degree of whiteness. There is a morbid feeling among the inhabitants of the metropolis which leads them to denounce *brownish* bread as decidedly bad bread. They think upon the eating of such bread with horror, though perfectly aware that the unadulterated home-baked bread of the country invariably possesses the detested colour. The prejudice in favour of white bread was probably excited originally by the bakers of London, for the purpose of promoting the sale of their own wares. They suc-

ceeded in persuading their customers that none but white bread was wholesome, and having done this, the use of home-baked bread which is always brown, must have necessarily declined. It is probable that the prejudice in favour of white bread was not established without some difficulty, and it is certain that the prejudice is now so deeply rooted that it would require extraordinary power to overcome it. But this is a thing which nobody chooses to trouble himself about. The people of London insist upon having *white* bread, and all that the bakers think of is to supply them with white bread. Now it is true that white bread in a state of purity can be produced by the employment of the very best wheaten flour, but the very best wheaten flour is always too dear to be employed by the bakers of bread, and the various sorts of flour which these gentlemen are in the habit of employing, are not endowed with the property of making bread of a white colour. The consequence is, that *the bread has to be* BLEACHED, and the bakers are obliged to bleach it. This is the cause of the introduction of bleaching materials into bread, the origin of a species of adulteration which is as much chargeable on the caprice of the public as on the cupidity of the bakers. The bleaching of bread would scarcely be practised, did not the prejudices of the consumers render the practice almost indispensable.

But though something may be said in vindication of *respectable* bakers, by whom no

greater adulteration is practised than is necessary to gratify the wishes of the public, and to enable them to employ flour which yields a living profit, there is nothing to be urged in favour of others in the profession who make use of every art which tends to the production of cheap and poisonous *sham loaves*. There is no prejudice in the public mind which favours the employment of bone-ashes, plaster of Paris and pipe-clay, as substitutes for the far-famed staff of life, nor should any mercy be shown to the scoundrels who are detected in attempting to practise so dangerous an imposition.

Detection of Alum in Bread.—The substance employed to bleach bread is alum. The component parts of this substance are *alumina, potash,* and *sulphuric acid*. The potash is difficult of detection, because there is no good precipitant for potash (p. 50), and because this substance forms but a small portion of the weight of the alum inserted into the bread. The detection of alum therefore depends upon the detection of alumina and sulphuric acid.—1. *To detect the Sulphuric Acid.* Cut two ounces of the suspected bread into thin slices, boil it for an hour in half a pint of distilled water in a Florence flask, and filter the solution through a folded filter of white blotting paper placed in a glass funnel. Pour the filtered liquor into a china saucer and evaporate it over a lamp until it is reduced to one-fourth of its original bulk. The presence of sulphuric acid is then to be sought for in

the manner described (p. 53). A very slight or a very copious production of sulphate of barytes may take place in this experiment. If a large quantity of sulphate of barytes is produced, the presence of alum in the bread may be pretty safely decided upon; but if a *small* quantity of sulphate of barytes is produced, it will not be safe to decide upon the presence of alum in the bread, although it will be proved that the bread contains sulphuric acid. The reason of this is, that the common salt which is employed in the making of bread, very generally contains a small quantity of sulphate of magnesia, and the latter salt acts towards a solution of chloride of barium in the same manner as a solution of alum. Bread made with salt freed from sulphate of magnesia, produces an infusion with water which does not become disturbed by the barytic test; but the cheap salt employed by bakers is seldom free from sulphate of magnesia. —2. *To detect the Alumina.* The solution filtered from the boiled bread must be evaporated to dryness, and the substance which remains must be put into a little spoon or crucible of metal, or in a piece of platinum foil, and heated to redness, either in a fire or before the blowpipe. By this means, the soluble organic substances extracted from the bread are decomposed. The mass left by the ignition is put into a mixture of muriatic acid or sulphuric acid and water, and the mixture is heated for a quarter of an hour over a lamp; it is then filtered through paper, and the clear

solution is tested for alumina by the usual reagents. A little of the liquor is put into several small test glasses. If *ammonia* is added to one of these portions, a white and very bulky precipitate appears, which cannot be dissolved by a large quantity of ammonia. A solution of *carbonate of potash* produces the same sort of precipitate as ammonia, and if the solution is concentrated, an effervescence takes place in consequence of the disengagement of carbonic acid gas. A solution of *caustic potash* produces a bulky precipitate which entirely dissolves if a greater quantity of the potash is added. It is necessary to add a solution of *muriate of ammonia* to the precipitate produced by ammonia. If the precipitate does not dissolve, the presence of *alumina* is determined, but if it dissolves in the muriate of ammonia, it may consist of *magnesia* instead of alumina.—When alumina is to be detected in bread or in any pasty or solid organic substance, it is unnecessary to extract the bread with water. It is simpler to ignite the bread in a small metallic vessel, and to heat the carbonised residue with acidulated water.—It is impossible to detect alumina by adding tests to solutions containing organic matter, and hence the necessity of first decomposing the organic matter by ignition.—The presence of alum in bread is proved, when both alumina and sulphuric acid have been detected. The potash may be sought after in the manner described (p. 50).

Detection of Lime in Bread.—It is here

necessary to give two processes; one for the detection of chalk and whitening, another for the detection of bone ashes and plaster of Paris.—1. Boil two ounces of the bread, cut into thin slices, in half a pint of water mixed with a little muriatic or nitric acid. Let the boiling be effected in a Florence flask over a lamp and continued for half an hour. Filter and evaporate the solution in the manner described (p. 126). If the solution is very acid, make it alcaline by adding ammonia in slight excess. Then pour into the mixture a solution of commercial superoxalate of potash. This will produce a precipitate of oxalate of lime. Warm the mixture, and when the precipitate has entirely subsided, filter the solution, bring the precipitate upon the paper filter, wash it, dry it, and heat it to redness in a metallic crucible or in a piece of platinum foil. Dissolve the ignited substance in muriatic acid, make the solution slightly alcaline by adding liquid ammonia, and then test it again with superoxalate of potash. If this re-agent produces a precipitate which is easily soluble in muriatic acid or nitric acid, but not in vinegar or dilute acetic acid, it will then be proved that the bread contains chalk or some other compound of lime capable of being dissolved by diluted muriatic acid.—2. When bread is suspected to contain plaster of Paris or sulphate of lime, the mass must be treated by the process given (p. 44), for the separation of sulphate of barytes from organic matters. The muriatic acid solution furnished

by that process is to be treated with ammonia and superoxalate of potash in the manner described above.—To detect the presence of the phosphate of lime which forms part of the bone-ashes, the mass produced by igniting the suspected bread, is digested with muriatic acid; the clear solution is decanted and mixed with ammonia, which produces a precipitate of phosphate of lime. If this precipitate is moistened with sulphuric acid and heated on a platinum wire before the blowpipe, it produces a pale yellowish-green flame. But bone-ashes can be partially separated from bread by a species of mechanical operation. The bread is digested with heat in a large quantity of water, upon which the bone-ashes separate from the pulp, and form a stratum of white powder at the bottom of the glass vessel which contains the mixture.

Carbonate of Ammonia.—This is a useful substance to bakers, who employ it to produce light and porous bread from spoiled or sour flour. The heat communicated to the dough during the operation of baking, converts this salt wholly into gas, which forcing its way in air bubbles through the stiff dough, renders it infinitely more porous than it would possibly become without such assistance. Not a trace of the carbonate of ammonia remains in the bread. But when the carbonate of ammonia contains lead, the bread is rendered poisonous.

Potatoes.—If this root is not employed *constantly*, it is certainly employed *largely*, as a cheap ingredient in loaves. Many bakers

assert that the introduction of potatoes serves to improve the bread. However this may be, the use of potatoes is certainly fraudulent, where it is not acknowledged and where no allowance is made in the price of the bread. When too large a proportion of potatoes is employed, the bread becomes moist, is softer and less elastic than wheaten bread, so that a slight pressure of the finger leaves an indelible mark on the crumb. Such bread soon turns mouldy.

Bean-flour.—Bread which contains horse-beans soon dries and cracks. It possesses a peculiar odour when toasted before the fire.—*Peas-meal.* Bread which contains the flour of peas soon dries and cracks, and is heavier and less porous than good wheaten bread.

Blue Vitriol.—This is the vulgar name for sulphate of copper, a substance which has on several occasions been inserted by bakers into wheaten bread. It is a violent poison. It was however extensively used at one period by some of the bakers at Bruges, for the purpose of fermenting bread without yeast. The method of detecting copper in bread has been described (p. 6.)

Cacao.—The best comes from Venezuela; the varieties from Berbice, Martinica and Brazil are of inferior quality. The nuts ought to be reddish-brown, somewhat brilliant, very brittle, rich, unctuous, and agreeably bitter. They must not be mouldy, nor white, nor possess a rancid or insipid taste. Small, dry,

very dark-coloured and very bitter or styptic nuts should be rejected.

Butter of Cacao.—It is sometimes adulterated with veal or mutton tallow, in which case it both smells and tastes of tallow, and is very liable to turn rancid.

Calcium, *Chloride of.*—It commonly forms a white mass, but can be procured in extremely large transparent crystals. It deliquesces very rapidly in the air, and easily dissolves both in water and alcohol. The solution is colourless and perfectly neutral. It must give no precipitate with pure caustic ammonia. A reddish precipitate indicates iron, a white one alumina. It must give no greenish-black precipitate with hydrosulphuret of ammonia, otherwise it contains iron.

Canella Alba.—Imported in long quill-like pieces of a pale buff colour, an agreeable aromatic odour resembling that of cloves or coriander, and a warm, pungent, and somewhat bitter taste. It gives a yellow powder.

Carraway Seeds.—The carraway seeds of English growth are generally preferred to the foreign, being more plump, fresh and aromatic. The Dutch seeds are apt to be musty and insipid.

Cardamom Seeds.—These seeds, contained in their pods, are imported from Bengal in large cases. Those which are small, broad and heavy, are preferable to the longer kinds, which contain fewer seeds and are less closely packed.

Carmine.—The carmines of commerce differ considerably in value and are never identical in composition. Their relative value is generally denoted by numbers. Most sorts contain more or less free alumina, and many contain vermilion, both of which substances are added as make-weights. The surest method of detecting these adulterations is to mix the carmine with liquid ammonia. This alcali has the property of dissolving pure carmine, but not of dissolving free alumina or vermilion, which can therefore be separated from the solution by filtration. The lightest carmine is the best, so that the value of various samples may be judged of by ascertaining the relative weights of equal measures. Sometimes, the adulterant in carmine is red lead. This may be detected by digesting the carmine in diluted nitric acid, and testing the solution for lead (p. 8).

Castor Oil.—It should be perfectly soluble in its bulk of alcohol of the specific gravity of 0·820. If it forms a milky mixture, or if any portion remain undissolved, you may suspect it to be adulterated with some of the more common fixed oils.

Catechu.—This is the substance formerly termed *terra Japonica*. Two varieties are imported from the East Indies; one possesses a reddish brown colour, a pulverulent form, and an astringent sweetish taste; the other has a resinous fracture, a brown colour, and a more astringent and bitter flavour. Both

kinds are liable to be largely adulterated with sand, starch and other impurities.

Cayenne Pepper.—The vegetable powder known under this name consists of a great many varieties of capsicum, mixed with a variable proportion, frequently with half its weight, of common salt. Chlorine and sodium, the constituents of common salt, may be detected by the process given (p. 58 and 51). Cayenne pepper is sometimes adulterated with coloured sawdust. It is also often mixed with red lead, to prevent its losing its colour on exposure to light. The presence of lead can be detected by the process described (p. 11).

Camomile Flowers.—They must be fresh, and when rubbed should give out their peculiar fragrance strongly. The large white flowers are preferable to the smaller kinds which become brown in drying. The double flowers are inferior to the single kind.

Cheese.—Cheese is coloured red by means of anotto, anotto is adulterated with vermilion, and vermilion with red-lead. The route is circuitous by which *lead* gets into cheese, but it *does* get there, and when there, the cheese is *poisonous*. I have given full instructions for the detection of lead (p. 11). It has been asserted that old ripe Stilton and other sorts of cheese are *greened* in particular parts by means of verdegris. This method of producing apparent old age conveys *copper* into the cheese. The presence of this metal

is readily detected by the processes described (p. 5).

Chocolate.—This alimentary preparation is made of roasted Cacao nuts and sugar, flavoured with certain aromatic substances, such as vanilla. The paste is often adulterated, previous to its formation into cakes, by the addition of *ground rice* and *potatoe-starch.* These substances change its taste but little, and when nicely incorporated, are not distinguishable by sight. When however such chocolate is prepared with water, it grows thick, exhales the odour of paste, and when the liquor cools, congeals to a jelly. This is not the case with good chocolate. Other manufacturers of chocolate extract the *butter of Cacao* from the pounded Cacao nuts, and supply its place by veal suet, oil of sweet almonds or even almonds in substance; but chocolate prepared in this manner soon becomes rancid, so that the cheat is manifested too speedily.—Just as the body of chocolate is tampered with, so is its spirit or aromatic part. Instead of vanilla, the manufacturer employs storax calamite, gum benjamin, and balsam of Tolu. These numerous substitutions cannot be detected by chemical means; but persons habituated to the use of good chocolate and who possess an exercised palate, can distinguish them with facility.—Good chocolate in cakes has a clear reddish-brown colour. When broken, the surface is smooth and uniform and not full of asperities. It melts readily in the mouth, with a sensation

of coolness, and ought not to taste rough or astringent.

Most varieties of chocolate contain a considerable quantity of iron, which, however, is not likely to render them unwholesome. They also contain a variable proportion of lime, derived from the stones on which the Cacao nuts are ground. CADET has calculated that a man who drinks a cup of chocolate every day, eats three ounces of lime in a year.

CINNAMON.—Cinnamon is said to be often adulterated by mixture with cassia bark, or with cinnamon bark from which the essential oil has been separated by distillation. The best method of distinguishing good cinnamon bark from bad, or from any other kind of bark, is to *taste* it. Those who are best acquainted with cinnamon have no other method of determining its goodness. Dr. Thornton gives the following account of the practice at Ceylon. "The tasting of barks to ascertain their quality is a very disagreeable duty imposed on the surgeons. It excoriates the tongue and mouth, and causes such intolerable pain as renders it impossible for them to continue the operation two or three days successively. In their turns, however, they are obliged to resume it, and they attempt to mitigate the pain by occasionally eating a piece of bread and butter."—*Family Herbal.* The cassia, however, may be distinguished from cinnamon by certain peculiarities. When you take it into your mouth, it forms a sweet mucilage, and seems when good to dissolve

almost entirely, whereas cinnamon has a hotter taste and produces a bitter dryness in the mouth. When cassia is infused in spirits of wine, it imparts a strong yellow colour to it, whereas cinnamon produces a much fainter-coloured solution. The quills of cinnamon bark are generally much thinner and smoother than those of cassia.

The genuine *oil of cinnamon* is exceedingly hot, sweet and aromatic, but its flavour when a little diluted is singularly rich and agreeable, and very different from that of oil of cassia, which is sometimes substituted for it and with which it is occasionally adulterated. It sinks in water.

CITRIC ACID.—The citric acid of commerce is found in the state of transparent, colourless crystals, which have a rhomboidal form and are very easily soluble in water, three parts of which dissolve four parts of the crystals. It is liable to be adulterated with *tartaric acid;* and very often tartaric acid is substistuted in bulk for citric acid. Large crystals of oxalic acid also have been occasionally found among the crystals of citric acid. To detect the presence of oxalic or tartaric acid, dissolve the suspected citric acid in water, and add to the solution a saturated solution of chloride of potassium or of acetate of potash. This will produce a crystaline precipitate of superoxalate or supertartrate of potash, if oxalic or tartaric acid be present. The solution of the suspected citric acid must be made with a very small proportion of water

for this experiment, because the superoxalate or supertartrate of potash, is soluble in a large quantity of water and therefore forms no precipitate therein. Another method of detecting the presence of oxalic acid consists in adding a solution of sulphate of lime to the solution of the suspected citric acid. This reagent produces a white precipitate of oxalate of lime.

If the presence of lime is suspected in the citric acid, dissolve the acid in water, make the solution alcaline with ammonia, and add a solution of oxalate of ammonia, which, if lime be present, will produce a white precipitate of oxalate of lime.

Crystalised citric acid is sometimes found to attract the humidity of the atmosphere. This is a sign that it contains a portion of *sulphuric acid.* To detect this acid, dissolve the citric acid in water and add to the solution a few drops of a solution of chloride of potassium. If this produces a precipitate, pour off the clear liquor and add to the precipitate a small quantity of muriatic acid. If the precipitate remains insoluble, the citric acid contains sulphuric acid. To place this quite beyond a doubt, however, it is necessary to try whether the precipitate contains any malate of barytes. (See p. 55.) Punch, lemonade, ginger beer, and similar compounds, are commonly prepared with tartaric acid instead of citric acid, when made up for sale. A solution of citric acid soon experiences spontaneous decomposition. The acid is con-

sequently best preserved in a crystalised state.

Cloves.—Good cloves are large, heavy and furnished with knobs or heads. They have a brown colour, an acrid burning taste, and a very penetrating but agreeable aromatic odour. They are easily cut by the finger nail, and exhibit traces of volatile oil where they are cut.—Good cloves are often mixed with cloves which have been deprived of their volatile oil by distillation. The latter are lighter than good cloves, shrivelled, and paler in colour; they give out no oil when compressed by the nail. When good and bad cloves remain long intermingled, the bad gradually absorb oil from the good, in which case the cheat becomes difficult of detection.

Cochineal.—The substance known in commerce by this name, is the dried body of an insect. It exhibits a small irregular body, generally convex on one side and slightly concave on the other, about the eighth of an inch in length and the twelfth of an inch in breadth. Its surface is wrinkled, and marked by distinct transversal lines. The principal sorts are the *black* cochineal and the *gray* cochineal. It is the latter sort which is subject to the arts of the sophisticator. The gray cochineal is exposed to the steam of water and then shaken with pounded talc or chalk in a long narrow leathern bag; after which it is sifted. The object of this operation is to make it look silvery and weigh heavier. If cochineal of this sort is macerated in warm

water, the powder separates and falls to the bottom of the vessel. Cochineal is often manufactured by mixing dust and refuse of cochineal with water and mucilage into a paste which is afterwards granulated to the size of the dried insect. This sort of cochineal falls to pieces when put into water, which is not the case with the real cochineal. Moreover, the artificial cochineal has not the distinct form and rings which are peculiar to the real insect.—Dyers are in the custom of chewing a few grains of the cochineal, in order to judge from the colour communicated to the saliva, of the colouring power of the insect. But the most exact method of determining the colouring power of a sample of cochineal is that recommended by Robiquet. Take a certain weight of cochineal of good quality and the same weight of the cochineal which is to be tried. Boil each in an equal quantity of water, and put an equal quantity of each solution into two little graduated glass jars or tubes. Add to each, a little at a time, a solution of chlorine gas in water, until the two red liquors are rendered yellow. The different quantity of the chlorine liquor required for the bleaching of each cochineal liquor, serves to point out the relative strength or colouring power of the two liquors; that which requires the most chlorine to bleach it, being, of course, the one which contains the most colour.

Coffee.—If you would have good coffee, you must buy it in the raw state, and roast

and grind it yourself. Raw coffee should have a greenish-yellow colour. It must not be mouldy nor worm-eaten. The French roast and grind their daily supply of coffee every morning, and the consequence is that they are never put to the disagreeable necessity of swallowing the weak, vapid, muddy, and unwholesome liquor which the English misnomer coffee. Roasted coffee rapidly loses its most valuable properties, even when not ground; but it loses them with exceeding rapidity if ground and then exposed to the air. When the volatile oil of roasted coffee has flown away, the solid residue or *caput mortuum* is utterly unable to communicate to hot water the smallest proportion of any useful property. There is no nourishment in coffee: it is valuable for its *spirit* alone; and this spirit, the French and all sensible people, take particular care to preserve. But of these important facts, the cooks and housewives of England are utterly ignorant, or knowing, wilfully disregard them. There is plenty of attention paid in this country to roast beef, and plum puddings, to cow heels, and calves' heads; but in the preparation of coffee, the English in general show themselves to be as destitute of ability, as if they were newly-caught savages set to perform the functions of cooking-animals for the first time. I think it is much to be regretted that the art of making good coffee is not more generally valued and practised among us. If the stupid ringleaders of the useless "temperance so-

cieties" would do something to put people into the way of getting and drinking good coffee, instead of preaching long sermons to them about the benefits derivable from sipping Port wine, their labours would have a clear and rational object. I will tell my countrywomen what they should do to keep their husbands from the gin-shop: they should teach themselves to make good coffee. A man would often take *that* at home, rather than more potent liquors abroad. I say *good* coffee, and mean thereby something different from a sort of wash fit only to be given to hogs to swallow, but which is nevertheless served up as a delicate beverage by many an English housewife to her unfortunate family. Good and strong coffee, made from berries which have been roasted and ground the same day, is an exceedingly exhilarating liquor, while poor, weak, slopped coffee does nothing but breed the blue-devils. A man would be a fool to resign his gin-and-water for this stuff; and the women are thoroughly foolish to expect them to do so. Let the latter begin by holding out to their husbands some temptation to stay at home to drink.

The operation of roasting coffee is very simple. It consists in slowly turning a tinplate cylinder containing coffee over a gentle charcoal fire. The operation is continued until the coffee assumes a bright chesnut colour, and acquires a fresh fragrant odour.

If you cannot *roast* your own coffee, you

should at any rate *grind* it. The grinding is still less difficult to do than the roasting. A day's supply of coffee can be ground in a minute. I have already told you, that ground coffee loses its goodness with great rapidity, and you may readily infer thence, that the coffee which is kept ready-ground at the grocers, is not good for much. But this is not the only thing to be thought of. When you buy coffee in the state of berries, you are sure that you get coffee; but when you buy a *brown powder* from the grocer, how can you satisfy yourself that the powder consists of coffee? Are you unaware that the following substances have been substituted by various grocers for coffee:—Pigeons' beans, peas, nuts, barley, rice, wheat, parsnips, carrots, horse-chesnuts, acorns, and particularly rye, and dandelion root—all as nicely dried, roasted, and ground as if they were genuine coffee? None of these articles resemble real coffee either in flavour or in exhilarating power. It is impossible, however, to distinguish sham coffee from spoiled genuine coffee, when the two are equally well ground. You must buy your coffee whole and grind it yourself, or you must submit to be cheated. There is no alternative. Chemistry cannot help you; for no experiments bating tasting and smelling, can distinguish good coffee from bad.

Columba Root.—This is generally kept in the shops in dried slices, which have a thick yellow bark covered with an olive-

coloured skin, and a browner and spongy central portion. It is commonly much worm-eaten. You should choose that which is as little so as possible. It ought to have a bright colour. It is liable to be mixed with slices of briony root, which have been infused in quassia water, and tinged with saffron. Columba, when moistened and touched with tincture of iodine, should become blackish, in consequence of the presence of starch; false columba presents no change of colour when treated in this manner. Pure columba gives no colour to sulphuric ether; false columba gives it a fine yellow.

Confectionery.—Lozenges, sugar-plums and various other articles of confectionery are liable to two kinds of adulteration. In the first place, the articles are increased in bulk and weight by the addition of *starch* and white *pipe-clay* instead of sugar; and secondly, they are made to tempt the eye by being coloured brilliantly red, by means of *red-lead,* and beautifully green by means of preparations which contain *copper*. Insoluble substances, such as ginger-lozenges, are particularly liable to the admixture of pipe-clay. The poisonous colouring matters are fixed upon a multitude of sweetmeats.—*To detect the Starch.* Dissolve or mingle the sweetmeats with water. Add a little nitric acid and then a drop of a solution of iodide of potassium or of any salt containing iodine. The presence of starch is indicated by the production of a

blue colour.—*To detect the Pipe-clay.* Boil the comfits in a large quantity of water; let the mixture settle, pour off the clear liquor, and collect the white powder at the bottom; it is the pipe-clay. If this is heated before the blowpipe on a piece of thin metal, or in a tobacco-pipe in the fire, it becomes hard like a piece of brick. Other tests for pipe-clay are given under the head of alumina (p. 47).—*To detect the Lead and Copper.* Follow the processes described (p. 8 and 2).

Copper, *Sulphate of. Blue Vitriol.*—It forms rhomboidal crystals, which possess a beautiful blue colour. It dissolves easily and completely in five parts of water, forming a blue solution which must remain clear on exposure to the air, and not deposit a basic salt of peroxide of iron. The solution, on being mixed with ammonia, must first deposit a precipitate; but an excess of ammonia must entirely re-dissolve the precipitate and produce a beautiful azure-blue solution. If a brown insoluble precipitate is formed, it is a certain sign of the presence of a considerable proportion of iron. If zinc is suspected to be present, it may be detected by proceeding as follows:—Acidulate the solution with sulphuric acid, and precipitate the whole of the copper by sulphuretted hydrogen gas; filter the solution from the precipitate; make it boil, and while it is boiling add a solution of carbonate of potash. If a white precipitate is produced, let it cool, then filter, wash, and dry it. If this precipitate becomes lemon-

yellow when heated and white when cold, the presence of zinc is demonstrated.

Copper, *Ammoniacal Sulphate of. Ammoniated Copper.*—It must form an ultramarine blue crystaline powder, or ultramarine blue octahedral crystals. It must completely dissolve in one-and-a-half parts of water. As it is extremely liable to spontaneous decomposition, it often happens that what has been preserved for some time in an apothecary's shop, particularly in glasses which have not been closed air-tight, is partially decomposed. It is then green or party-coloured, and will no longer dissolve in water. If it leaves a brown powder when dissolved in nitric acid, it contains iron.

Copper, *Acetate of.*—(*a*) *Common Verdigris.* Boil the verdigris in twelve or fourteen times its weight of distilled vinegar, allow the solution to settle, and separate the insoluble matter by filtering the liquid through paper. This insoluble matter consists of pieces of copper, grape stalks and other impurities. To the filtered solution, add a solution of acetate of barytes, or of chloride of barium. If either of these produces an abundant precipitate, pour off the supernatant liquor and add muriatic acid to the precipitate. If the precipitate dissolves, the verdigris contains tartrate of copper. If it does not dissolve, the verdigris contains sulphate of copper.

(*b*) *Distilled Verdigris.* This is prepared by dissolving the common verdigris in distilled vinegar and crystalising the solution. Dis-

tilled verdigris is frequently adulterated with sulphate of copper, which can be detected in the manner described above.

(*c*) *English Verdigris.* A substance sometimes met with in commerce under the name of English verdigris, is prepared by triturating acetate of lead and sulphate of copper with a certain proportion of chalk and water; the mixture is dried in cakes with a quantity of grape stalks to give it a genuine appearance. To analyse this substance, digest it in water, separate the solution by filtration and examine the insoluble matter for sulphate of lead (p. 9) and sulphate of lime (p. 45). The filtered liquor may also be tested for sulphuric acid by a solution of chloride of barium.—Verdigris is an acetate of copper, and when pure, dissolves in water without leaving any residue.

Crabs' Eyes.—These concretions are round, convex on one side and concave on the other, with a circular projecting edge; they are white, smooth, very hard, inodorous and tasteless; internally, they are formed of concentric couches strongly united by animal mucilage. Artificial crabs' eyes are formed of burnt bones and carbonate of lime, cemented by glue and shaped by a mould. But these crabs' eyes do not exhibit internally the lamellar structure of the true sort, and they are distinguished by falling into pieces when put into boiling water, and depositing a precipitate of salts of lime, whereas true crabs' eyes are not acted upon by boiling water.

Cream.—Cream, being an article in con-

siderable demand and bearing a high price, is frequently adulterated with compounds containing starch and skimmed milk. Arrow-root is the substance which is best adapted and most employed for this purpose. It is mixed and boiled with skimmed milk into a thin paste, and after cooling is mixed with genuine cream in various proportions. The fraud may be detected by adding to the cream a solution of iodine in alcohol, or by adding a little nitric acid to the milk, and then a few drops of a solution of iodide of potassium. Either of these tests communicates a blue colour to cream which contains arrow-root, rice powder, flour, or any other substance of which starch is a constituent.

Dragon's Blood.—This is a resinous substance of a deep red colour, friable, of a glistening fracture, inodorous, tasteless, insoluble in water, soluble in alcohol with the exception of a slight woody residue; its powder has a brilliant vermilion-red colour; when thrown on burning coals, it disengages an aromatic odour.—False dragon's blood consists of different resins coloured with red sandal, colcothar, Armenian bole and pure dragon's blood. It has not the shining red fracture of true dragon's blood; its powder has a dull colour; it disengages a disagreeable odour when thrown on burning coals; it dissolves in alcohol, but leaves a very considerable residue.

Electuaries.—Electuaries are mixtures composed of powders, pulps and extracts incorporated by means of honey, syrup, wine, or

some other liquid. They are more liable to be adulterated with impunity than any other species of compounds, for which reason, no person who can possibly avoid it should purchase them ready prepared. Liquorice, gentian, starch, and a variety of neutral substances are employed by certain druggists in the preparation of electuaries of every description.

Extracts.—An extract is the juice, or the infusion or docoction of a plant, evaporated to a thick pasty consistence. Extracts which contain expensive substances are very liable to be adulterated with extracts possessed of no virtues. Frauds of this kind are difficult of detection, for which reason every apothecary ought to prepare his own extracts, and not buy them ready prepared.

Flour.—When you are about to try the quality of flour, proceed as follows :—Grasp a handful, give it a sharp squeeze, and set the lump on a table. If it holds together and preserves the form of the cavity of the hand, the flour is good; but if the lump soon falls down, the flour is adulterated. When the adulterant is ground bones or plaster of Paris, the lump of flour falls down immediately; but when whiting or pipe-clay is present, the lump keeps its form a little longer. The presence of much bran is detected by the colour and feel of the flour; but in this case also the grasped specimen soon crumbles. Genuine flour retains the fine impressions of the grains of the skin much longer than any

which is adulterated.—Rub a little of the flour between the palms of your hands when they are moist: if you find any resistance, the flour contains whiting.—Moisten the fore-finger and thumb with a little sweet oil and rub a small quantity of the flour between them. If the flour is pure, you may rub it for any length of time without its becoming sticky and adhesive; the flour in the meantime becomes nearly black. But if whiting be present, the flour will soon be worked up into the consistence of putty, which will retain the original white colour or nearly so.—Mix a little flour with water in a tumbler, then drop a little muriatic acid into the water. If any chalk or whiting be present, an effervescence will be produced by the discharge of carbonic acid gas.—Knead a small quantity of the flour with water. If good, it forms an adhesive, ductile and elastic paste, which you may draw, flatten or elongate in every direction, without separating it into pieces.—Taste the flour. You can thus ascertain the presence of *sharp whites* and *stuff* (mixtures which contain *alum* and *salt*).—Sprinkle a little of the flour over black paper and examine the grains with a microscope. If you perceive a number of brilliant particles, the flour has been mixed with ground potatoes. The microscope also detects the presence of insects in flour.

Gin.—Pure gin is prepared by re-distilling malt spirit over juniper berries; but the common kind of English gin is flavoured by spirit of turpentine instead of oil of juniper. The

retailers of gin dilute it largely with water and sweeten it with sugar. The addition of water renders it turbid, in consequence of the precipitation of the volatile oils which it contains. It is consequently necessary to add something to clarify or give it a good *complexion*. (See article "Brandy," p. 122).

The clarification can be effected by two methods. The first consists in adding to the turbid mixture, first a solution of alum and then a solution of carbonate of potash. The other method consists in adding in the same manner a solution of sugar of lead and a solution of alum. The whole mixture is in either case well stirred together, and then left undisturbed for twenty-four hours, at the end of which time it is perfectly limpid and fit to be drawn from the dregs. It generally happens that the latter process (which is usually preferred in consequence of its superior efficacy) leaves a portion of lead in solution, and thus renders the gin poisonous. But the gin-spinners consider this to be of no importance, provided the liquor can be made to sell. On this account, the public should look to it themselves, if they are desirous of avoiding death; although, indeed, it is a matter of no great importance, so far as a considerable number of incurable gin-drinkers are concerned, whether they be poisoned or not: the lives of many of them are utterly useless and miserable, and their deaths may be looked upon as occurrences which rid society of worthless clogs and wretched examples of

human degradation. This is speaking contemptuously of men, but only of such men as labour to render themselves contemptible.

Detection of Sugar.—Evaporate the gin to dryness in a small capsule or table-spoon. The sugar remains behind in the form of a gummy extract.

Detection of Alum.—Concentrate the gin by evaporation and then apply the necessary tests for the detection of sulphuric acid (p. 53). You may also, if you please, continue the inquiry by applying to the concentrated liquor the tests for alumina (p. 47), and potash (p. 50).

Detection of Lead.—Concentrate the gin by evaporation, and then expose the solution to the tests for lead which are given (p. 8).

Detection of Sulphuric Acid.—It is stated that this liquid is sometimes added to gin, to give it apparent strength. Its presence may be detected by the process described (p. 53).

Detection of Water. The actual strength of gin depends upon the quantity of alcohol it contains. When gin is pure, its strength may be estimated by the hydrometer (see alcohol, p. 79); but when its specific gravity has been affected by the addition of sugar or other matters, this method of proof is incompetent to give satisfactory results. The method of examination proper to be adopted in such a case, is to separate the alcohol from the non-volatile adulterants by distillation, and then to try the strength of the distilled product. Instructions relative to the performance of this

operation will be given in the article on "Wine."

Gum Arabic.—Gum arabic is frequently replaced by Gum Senegal, the small, colourless, dry and friable pieces of which are selected and devoted to this substitution. Gum Senegal is more clammy than gum Arabic, and is frequently covered with fine sand, which on all occasions when the gum is to be put into food, ought to be washed off.—Gum Arabic is also sometimes replaced by the gum which exhudes from our plum-tree and cherry-tree. This gum is much inferior, both to gum Arabic and gum Senegal. It is generally in irregular pieces, strongly coloured and much less brittle than gum Arabic. When put into water it dissolves but partially, whereas gum Arabic and gum Senegal are completely soluble.

Gum Arabic in Powder.—This, as sold in the shops, is generally adulterated with *starch* or *wheaten flour*. I have detected *sulphate of lime* in large quantity in powdered gum Arabic. Shake a pinch of the gum with a little cold water in a glass tube. The gum dissolves, and the starch and flour fall to the bottom in powder. If sulphate of lime is present, it falls down with the starch.—Boil the gum in water, add a little nitric acid, and then a few drops of a solution of iodide of potassium or of any salt containing iodine. The production of a blue colour denotes the presence of starch or flour. Mix a little of the suspected gum with a drop of water to a dough, fix this on

the end of a platinum wire and calcine it in the flame of the blowpipe. If it does not burn quite away, but leaves a substance which shines very brightly when the blowpipe flame is directed on it, and which is insoluble in water, the gum *probably* contains *sulphate of lime.* The doubt can be decided by the experiment described (p. 45). But, at any rate, the incombustible substance is not gum.

Syrup of Gum Arabic.—The liquid sold under this name is seldom any thing else than the mother liquors of sugar candy or the syrup of sugar, deprived of colour by being agitated with animal charcoal and then filtered. It is possible to determine whether a liquor contains gum, by adding alcohol to it. This precipitates any gum which may be present, in the form of copious white flocks.

Gums, Resins *and* Balsams.—Gums, gum-resins and balsams, which form so large and important a part of the materia medica, are extremely liable to sophistication. It is a common practice to dissolve these drugs, and in reducing them to a dry consistence, to mix them, either with heterogeneous matters resembling the drugs in appearance, or with such foulness as is natural to them in consequence of the manner of their production. But as this admits of a great variety of circumstances, and as the drug manufacturers often exercise much ingenuity in their sophistications, it is impracticable to lay down any particular rules for the judging of, or proving

the purity of such substances. The easiest method is to compare each kind with a well-chosen specimen of the genuine article; by which the degree of adulteration or of alteration in apparent qualities, will be best perceived. In certain cases, it is advisable to dissolve the suspected article in its proper menstruum, when the deposition of an insoluble substance, such as *starch*, evinces the adulteration. This substance may also be detected by means of iodine. (See p. 153.) Balsam of Copaiva and Venice turpentine are very often sophisticated with common turpentine; the latter indeed, is sometimes substituted in bulk in the place of the former. Balm of Gilead, balsam of Peru, and other expensive balsams are extremely liable to adulteration with turpentine or other cheap substances.—The several species of the turpentine genus are easily distinguishable from one another when they are alone; but when they are compounded with each other, or mixed with bodies of a different nature, it is very difficult to ascertain the exact degree of their purity. Some judgment may be formed from the peculiar odours of the different balsams; but the best method of examining them is to bring them into comparison with specimens which are known to be good.

HARTSHORN.—Shavings of hartshorn are often adulterated with shavings of mutton-bone. The latter are distinguished by their greater degree of brittleness.

HOG'S LARD.—It should be white, granular,

and rather firm in texture. The pork-butchers adulterate it with other sorts of pork fat, which give it a dark colour, a disagreeable odour and a softer texture. They also sometimes mix it with fat skimmed from the surface of water in which various parts of the pig have been boiled. Lard when thus adulterated, has a gray colour, a very soft consistence, and a salt taste.

Honey.—The honey of commerce often contains a certain proportion of *starch* or *bean-flour*, which is added to it to give it whiteness and weight. But this is a cheat which it is easy to detect. It suffices to mix the adulterated honey with a small quantity of cold water. The honey instantly dissolves, while the starch or flour falls to the bottom of the vessel, in powder. If honey of this sort is exposed to heat, it is first rendered liquid, but as it afterwards cools, it solidifies and becomes tenacious.

Hops.—Good hops have a bright olive-green colour, and an aromatic odour. When rubbed they feel oily or clammy, and the friction produces a quantity of fine yellow dust. Hops which smell of *sulphurous acid* have been bleached by exposure to the fumes of sulphur. They are then worthless. The proper way to try hops is to rub them in the palm of the hand, and then to examine their aromatic odour and the quantity of yellow dust they produce. This enables you to judge of their condition.

Iodine.—It should form brilliant slate-

coloured scales. It must be very slightly soluble in water, and very easily soluble in alcohol, forming a yellowish-brown solution. It must volatilise without residue, producing violet vapours. If brilliant fragments of slate, or pieces of coal or plumbago are mixed with it, they remain behind, not only when the iodine is volatilised, but when it is treated with alcohol.

Ipecacuanha.—The author of "*Deadly Adulterations*," tells us that "as this drug is sold to the public in a pulverised state, there is no ready test for discovering its purity, although it is adulterated with tartar emetic." This gentleman must be informed that tartar emetic contains antimony, a metal which is particularly easy of detection. I refer the reader to p. 14, for instructions for the detection of antimony. I believe that ipecacuanha is more frequently adulterated with other roots, which, though similar to it in appearance, are totally destitute of the powers by which ipecacuanha is characterised. The roots of ipecacuanha are twisted and marked with numerous small but deep circular rings; internally it exhibits a small white woody fibre, from which the thick gray bark is detached with difficulty. The bark should be compact, brittle, resinous, nearly inodorous, but bitter and rather acrid.

Ipecacuanha Lozenges.—These are frequently prepared with tartar emetic instead of ipecacuanha, a substitution which is capable of producing serious accidents. If the false

lozenges are dissolved in water, they produce a clear solution, whereas the true lozenges give a precipitate of ipecacuanha. The solution produced by the false lozenges, gives an orange-red precipitate when tested with liquid sulphuretted hydrogen (p. 14).

Iron.—It requires to be particularly examined for zinc and copper. It must be dissolved in nitric acid, nitro-muriatic acid or sulphuric acid. If it does not dissolve easily in the latter, it probably contains tin or brass. If there is any residue, it must be dissolved in nitro-muriatic acid. The solution must be boiled with nitric acid, to convert the iron into peroxide. The solution must then be mixed with an excess of ammonia, which precipitates the whole of the iron as a brown hydrate. The filtered solution must not be blue, otherwise it contains copper. It must be neutralised by sulphuric acid and tested with a solution of prussiate of potash. If it gives a red precipitate, it certainly contains copper. If it gives a white precipitate, it contains zinc.

Iron Filings—Are very liable to contain copper. If shaken with liquid ammonia in a glass tube and exposed at the same time to atmospheric air, the copper communicates a blue colour to the ammonia.

Iron, *Black Oxide of.—Martial Ethiops.* It must be quite black, magnetic, easily soluble in muriatic acid, with difficulty soluble in sulphuric acid without disengagement of hydrogen gas. Its recent solution gives green pre-

cipitates with the alcalies. It must not become blue when mixed with an excess of ammonia, otherwise it contains copper.

IRON, *Red Oxide of*.—It must have a lively red colour. If it is yellowish, it contains hydrate.—It must dissolve entirely in muriatic acid otherwise it contains pounded brick, and should produce a reddish brown solution. This must give reddish brown precipitates with the alcalies, without any tendency to green. —Colcothar, or the residue of the preparation of sulphuric acid from green vitriol, is red oxide of iron in an impure state. It commonly contains copper, tin, and a portion of basic sulphate of iron. It is unfit for medical use.

IRON, *Sulphate of*.—The common sulphate of iron, or green vitriol, of the shops, often contains copper, the presence of which may be detected by inserting a clean plate of iron into its solution. (See p. 4.) After exposure to air, it always contains a quantity of free oxide of iron, known by an ochrous appearance. Pure sulphate of iron has a bluish-green colour. When it has something of an emerald colour, it is impure. To determine with accuracy the presence of copper or zinc in green vitriol, proceed as follows :—Dissolve the salt in water and boil it with a small quantity of nitric acid until it becomes clear, adding more nitric acid if necessary. Precipitate the oxide of iron by an excess of ammonia. If much copper is present, the liquid will then be blue. Neutralise the ammonia by sulphuric acid, and add a solution of yellow prussiate of potash. If this pro-

duces a red precipitate, it indicates the presence of copper; if it produces a white precipitate, it indicates the presence of zinc.

Isinglass.—Isinglass is prepared from the air-bladders of the sturgeon. It is found in commerce under various forms, such as large strings, small strings, and leaves. It is always white, semi-transparent, dry, fibrous, horny, of a faint odour and insipid taste. The best sort is twisted into the form of a horse-shoe. When a very thin leaf is moved between the eye and the light of the sun, a species of chatoyance is perceived. If macerated in cold water, isinglass swells and softens; if boiled in water, it dissolves almost without any residue and forms a solution, which on becoming cool produces a semi-transparent and solid jelly.—The high price at which isinglass has always been sold, has given rise to the production of a vast quantity of factitious isinglass, most species of which are characterised by their imperfect solubility in boiling water.

Factitious Isinglass in leaves.—This substance, which appears to be an intestinal membrane of the calf or sheep, is in thin, regular, flexible leaves; white in colour, semi-transparent but not chatoyant; without odour but salt in taste. The leaves are eight or ten inches long, and two or three inches wide. When torn, they divide in any direction, whereas the true isinglass tears only in the direction of the fibres. It is less transparent than true isinglass, even when thinner in substance. If a piece of it is macerated in water

it softens and tumefies, but then, instead of preserving its form like true isinglass, it falls into little lumps and presents the appearance of curds and whey. Treated with boiling water, it leaves a residue of about one-third of its weight, and gives a liquor which does not form a jelly; whereas good isinglass, treated in the same manner, dissolves almost entirely, and invariably produces a jelly. These characters, and particularly the salt taste, the total absence of chatoyance, and the small size and regularity of the leaves, are sufficient to enable one to distinguish the false isinglass with facility.

Factitious Isinglass in small strings.—A great quantity of isinglass is found in commerce, in the form of small strings, of a quality very much inferior to that of true isinglass. This sort is probably prepared from other membranes than those of the air-vessels of the fish. It has a dull gray colour, and a horny appearance, and offers here and there traces of that chatoyance which I have spoken of above. Boiling water dissolves about the half of it, producing a grayish troubled jelly, and leaving a bulky, watery, elastic residue. If the decoction is made in a silver vessel, the silver is turned black, from which it may probably be inferred that this variety of isinglass has been bleached by sulphurous acid. It is very probable that this substance is prepared from the skin and other cartilaginous parts of the sturgeon. It bears not more than the fourth part of the price of the best sort of isinglass. Hence

it is a common practice to substitute the one for the other, or to mix the two together for sale. The great external resemblance which the two sorts bear to one another, renders it difficult to distinguish them. It is consequently advisable not to buy isinglass in large quantities without making a previous trial of its goodness by ascertaining the degree of its solubility in boiling water.

Ketchup, *Catsup, or Catchup.*—These three words indicate a sauce, of which the name can be pronounced by every body, but spelled by nobody. True ketchup is the liquor produced by the liquefaction of salted mushrooms. A false sort of ketchup is produced by adding a variety of spices to a decoction of the outer green husk of the walnut. Both true and false ketchup are occasionally contaminated by copper, but the false ketchup most generally so and often to a very dangerous extent. The presence of this metal, even when it occurs in an extremely small proportion, can be infallibly detected by the methods described in the article on copper at page 2.

Lakes.—The colouring substances termed lakes, dissolve without residue when boiled in a concentrated solution of potash. This is the case both with madder and carmine lakes.

Lead, *Acetate of. Sugar of Lead.*—It must be in perfectly white crystals, not in powder. It should be preserved in glasses, closed with accuracy against the air, otherwise it effloresces and becomes partly converted into carbonate of lead. It is blackened by sulphuretted hy-

drogen. It must dissolve easily and completely in water or in alcohol, otherwise it contains carbonate of lead. After the solution has been precipitated by an excess of a solution of sulphate of soda, and the precipitate has been separated by filtration, the clear solution must not become red when tested with a solution of yellow prussiate of potash, otherwise the sugar of lead contains copper.

Solution of Subacetate of Lead.—This liquid is best prepared by boiling litharge in a concentrated solution of sugar of lead, in a porcelain capsule, for ten minutes, or until the liquid is alcaline and renders turmeric paper brown. It should then be filtered and preserved in well-closed vessels. It must be a perfectly colourless solution. When it is brown, it has been prepared from the residuum of the distillation of vinegar, or by boiling litharge in common vinegar. In either case it is unfit for medical use. When the liquid appears green, it contains copper, which may be detected by first precipitating the lead by an excess of a solution of carbonate of ammonia, and then testing the filtered solution by a solution of yellow prussiate of potash, which, if copper is present, will produce a red precipitate.

Goulard Water. This liquid consists of the above solution of subacetate of lead, mixed with alcohol and diluted with distilled water, which should be previously boiled to free it from carbonic acid. Good goulard water is quite transparent; when it is milky, it contains carbonate of lead.

LEAD, *Carbonate of. White Lead.*—Pure white lead is a carbonate of lead, or a compound containing the following elements:—lead 52 parts, carbon 3 parts, oxygen 12 parts. The substances with which it is commonly adulterated are chalk, sulphate of lead, and sulphate of barytes.

Detection of Sulphates. Mix a little of the suspected white lead in a florence flask with water and nitric acid, adding the white lead or the acid gradually, to render the effervescence moderate. Boil the mixture over a lamp for a few minutes. If the white lead dissolves entirely, it is free from sulphates. If it leaves a precipitate, let the solution settle, filter it, and wash the precipitate on the filter till the liquor which runs through it gives no precipitate when tested with a solution of sulphate of soda. Test the precipitate for sulphuric acid by the processes described at page 53.

Detection of Barytes.—The precipitate furnished by the preceding experiment may consist of sulphate of lead, sulphate of barytes, or of a mixture of both of these compounds. Boil a small portion of the precipitate in a glass tube or small matrass, with a solution of caustic potash. If it dissolves entirely it is sulphate of lead. If it leaves a residue, the residue will be sulphate of barytes. Dilute the solution with water, filter it, wash the insoluble matter and submit it to the tests for sulphate of barytes which I have given at p. 43. Neutralise the solution filtered from the sulphate of barytes, by adding muriatic acid; then add

a little liquid sulphuretted hydrogen. If it contains lead, a black precipitate will be produced. When the precipitate consists of sulphate of lead alone, it dissolves without residue in the solution of potash, and the resulting solution gives a black precipitate with the liquid sulphuretted hydrogen. When sulphate of barytes alone is present, the solution of potash leaves a residue, and the filtered liquor affords no black precipitate when tested with liquid sulphuretted hydrogen. When the precipitate contains both lead and barytes, the solution of potash both leaves a residue of sulphate of barytes, and affords a black precipitate when subsequently tested with liquid sulphuretted hydrogen.

Detection of Sulphate of Lead.—If you merely wish to know whether the precipitated sulphate contains lead, you may moisten it directly with liquid sulphuretted hydrogen. If lead is present, the mass turns black. Of course it must previously be carefully freed by washing from nitrate of lead.

Detection of Chalk.—Boil a little of the suspected white lead in muriatic acid diluted with a small portion of water. Add alcohol to the solution and filter it: the lead will remain on the filter in the state of chloride of lead, and will be accompanied by the sulphates which were present in the white lead. The filtered solution will contain chloride of calcium, provided the white lead contained chalk. You may neutralise the solution with ammonia and precipitate the lime by means of oxalic

acid, as I have described at p. 45; or you may evaporate the solution to dryness, and expose the drysalt on a clean platinum wire, moistened with a little water, to the flame of the blow-pipe, to which it will communicate a crimson colour.

The process for analysing white lead which is given by ACCUM, "*Culinary Poisons, fourth edition*, p. 29," is as follows:—"It should be completely soluble in nitric acid, and the solution should *remain transparent* when mingled with a solution of SULPHATE *of soda*." This sentence is a striking example of that inaccuracy which is so characteristic of the processes detailed in most of our popular receipt books.

LEAD, *Chromate of. Chrome yellow*.—The rich yellow colour of this substance enables it to bear the addition of a great quantity of foreign matter without any sensible deterioration in appearance: hence, it is extremely liable to adulteration. The substances most commonly found in it are the following:—carbonate of lime, carbonate of lead, sulphate of lime, starch.—Mix a little of the chromate of lead with water, and add a few drops of nitric acid. If an effervescence takes place, it denotes the presence of *carbonates*.—Mix a little of the chromate with a quarter of its weight of charcoal, and make the mixture red hot in a crucible. Pound the calcined mixture, and boil it in a flask in a mixture of water and muriatic acid. If it gives out the odour of sulphuretted hydrogen gas, it denotes the presence of *sulphates*. Filter the liquor, which

will be green, through a paper filter, and render it alcaline by the addition of ammonia. A precipitate will appear, consisting of oxide of chromium, &c. Filter the liquor once more, and add to the filtered liquor a solution of oxalate of ammonia, or of oxalic acid, taking care that the liquor continues to be alcaline. If this produces a white precipitate, it denotes the presence of *lime.*—Burn a portion of the chromate by itself in a crucible. If it produces a smoke and gives out the odour of burning vegetable matter, it denotes the presence of *starch;* or boil a portion of the chromate in water, and test the liquor for starch by means of preparations of iodine (p. 153.)

LEAD, *Protoxide of. Litharge.*—This is found in commerce in the form of small thin transparent scales, which are commonly produced by the artificial oxidation of lead in the treatment of argentiferous lead-ores. When pure it is yellow, but its powder has a reddish hue, and the litharge of commerce has often a strong red colour, arising from the presence of red lead or of iron. The best solvents for litharge are the nitric and acetic acids. When it does not entirely dissolve in these re-agents, it is impure.—Litharge often contains copper and lead, the presence of which metals can be detected by the following process:—Dissolve the litharge in pure nitric acid, filter the solution from the insoluble matter, if any, and precipitate the lead by adding a solution of sulphate of soda as long as it troubles the liquor. Separate the precipitate by filtration,

and mix the solution with liquid ammonia. If the litharge contains copper, the ammoniacal solution will assume a blue colour. If it contains iron, the addition of the ammonia will occasion the production of a brown precipitate.

The litharge of commerce often contains silica, and occasionally it is intentionally mixed with red micaceous sand. But as acetic acid dissolves litharge completely, without having any effect upon silica or sand, the presence of such adulterants is extremely easy of detection.

LEAD, *Red Oxide of. Red Lead.*—There are very few substances to be found, which can be mixed with red lead without depraving its brilliant colour. Nevertheless, it has been often met with, contaminated by brick-dust or red ochre. *Detection of brick-dust.*—Heat the red lead red-hot in an earthen crucible, and then dissolve it in diluted nitric acid. If brick-dust is present it remains undissolved.

Detection of red ochre.—Boil the red lead in muriatic acid; dilute the solution with water, and filter it. Add to a portion of the clear solution a solution of yellow prussiate of potash, and to another portion an excess of a solution of caustic potash. If the first reagent produces a dark blue precipitate, and the second a brown precipitate, the red lead contains red ochre. Or the nitric acid solution may be tested for copper and iron in the manner described in the article on "Litharge."

LEMON JUICE.—The juice of the lemon, lime, currant, and other fruits, contains a

peculiar acid, which is known to chemists as the citric acid. The agreeable flavour of this acid, both in its pure state and as it exists in the juice of the above-named fruits, has made the use of it very general.

The citric acid is sometimes employed in the state of *lemon juice.* This is prepared by submitting to pressure the pulp of lemons, or limes, previously freed from the skins and seeds. The expressed juice is allowed to repose several days, and is then decanted and filtered. The liquor thus prepared has a yellow colour, and an agreeable and peculiar acid taste. It consists of a solution of citric acid in water, accompanied by a little malic acid and a considerable quantity of saccharine and mucilaginous matter. When fresh made, it can be applied to many useful purposes; but owing to the presence of the last-named substances, it is extremely liable to spoil. There is only one remedy for this inconvenience, which remedy consist in reducing the citric acid of the lemon juice to a state of purity, by freeing it from the sugar and mucilage, the fermentation of which is the cause of its decomposition.

To prepare citric acid, you saturate the lemon juice with chalk, wash the insoluble citrate of lime, and then decompose it by diluted sulphuric acid, taking care to add such a proportion of the latter as is just sufficient to saturate all the lime, and leave the pure citric acid in solution, unaccompanied by sulphuric acid. You allow the mixture to settle, and

then remove the clear liquor by decantation. The citric acid is reduced to the solid state by evaporation and crystalisation. It is at first brown, but after a second or third crystalisation becomes white.

Lemon juice is sometimes *diluted with water:* this may be detected by ascertaining the strength of the acid. One part, by weight, of dry subcarbonate of potash should neutralise nine parts, by weight, of lemon juice.—It is sometimes adulterated with the *mineral acids;* but these may be detected by the processes given under the head of "Vinegar" (p. 72).

The fraud which is most frequently practised with lemon juice is that of substituting *tartaric acid* instead of it. But it is easy to detect this adulteration. It suffices to drop into the suspected lemon juice a solution of acetate of potash, or of chloride of potassium. This in a short time produces a precipitate of supertartrate of potash, which appears in the form of small transparent crystals. No such phenomenon is produced with pure lemon juice, because the citrate of potash, being a very soluble salt, is not susceptible of precipitation under the above circumstances.

Syrup of Lemons, produced by dissolving white sugar in purified lemon juice, is often replaced by a mixture of sugar and tartaric acid. The presence of the latter acid can be detected by means of the test above indicated. But the precipitation is effected very slowly in this case, in consequence of the viscosity of the liquid.

Lime.—Pure or caustic lime is prepared by exposing carbonate of lime to a strong red-heat. The purer the carbonate of lime employed, the purer is the resulting lime. Perfectly pure lime is obtained by igniting the crystalised double spar of Iceland. For common purposes, limestone is employed; but it must not be such as contains alumina. It is consequently improper to employ chalk, which is generally impure; and the lime which is prepared from oyster-shells is always contaminated by phosphates. When pure lime is moistened with water, it becomes very hot, smokes strongly, and falls to a fine powder. With a little more water it forms hydrate of lime. If the lime does not act in this manner when treated with water, but retains its original form, it either contains alumina or carbonate of lime. The presence of the latter is easily detected by the effervescence which is produced when a little dilute muriatic acid is added to the moistened lime.

Lycopodium.—It is sometimes mixed with talc or with starch. Make a paste of the lycopodium with water and mix it with a large quantity of water; the lycopodium will swim and the talc sink. Boil the lycopodium in water, and test the liquor by tincture of iodine or solution of iodide of potassium and nitric acid. If a blue colour is produced, it indicates the presence of starch.

Magnesia.—There are two species of magnesia commonly employed in medicine. The first is pure magnesia, usually termed

calcined magnesia; the second is carbonate of magnesia, but generally termed *magnesia,* with no qualifying word.

(*a*) *Calcined Magnesia.*—This should form a light, perfectly white, tasteless and inodorous powder. It should dissolve without effervescence in acids, otherwise it contains carbonate of magnesia, which is a very common adulterant. To put this latter property to proof, you throw a pinch of the magnesia into a little very dilute acid, or mix the powder with water and then add a few drops of acid. It is indispensable to the success of this experiment that the acid be very much diluted with water; because it is possible to produce effervescence by adding a concentrated acid to magnesia which is entirely free from carbonic acid. The effervescence is due in the latter case to the sudden evaporation of a portion of acid and water, occasioned by the elevation of temperature produced by the mixture of the two substances. This elevation of temperature can be so great as even to occasion incandescence, which, indeed, is the effect produced, when magnesia, recently and strongly ignited, is mixed with very concentrated oil of vitriol. Calcined magnesia should dissolve in acids without residue; but when the calcination has been very strong or long sustained, it often happens that the last portion of the substance dissolves very slowly. When the magnesia contains silica, the latter remains undissolved in the acid solution. The other adulterants of calcined magnesia are the

same as those contained in carbonate of magnesia; directions for the examination of which are given in the next paragraph.

(*b*) *Carbonate of Magnesia.*—The magnesia of commerce often contains carbonate of lime. This is sometimes added fraudulently, and sometimes arises from the presence of calcareous salts in the compounds employed in the preparation of magnesia. This is the case when the mother-waters of nitre or of sea salt are made use of in this manufacture. To detect the presence of lime in magnesia, you must proceed as follows:—Dissolve the magnesia in muriatic acid and filter the solution. (*a*) Evaporate a portion of the solution till it produces a thick mass, and expose this mass on a clean platinum wire to the flame of the blowpipe. If it produces a red flame, it proves the presence of lime, for magnesia does not produce a coloured flame before the blowpipe. (*b*) Neutralise the acid solution with ammonia, dilute it with water, and add to it a solution of oxalate of ammonia or of superoxalate of potash. If this produces a white precipitate, it demonstrates the presence of lime.

Magnesia should contain no soluble substances. Boil a portion of it for a quarter of an hour in ten parts of water, and filter the solution. The clear liquor should have no taste, be without action on turmeric paper, otherwise it contains alcali, and should give no precipitate with a solution of nitrate of silver, otherwise it contains muriatic acid, or

of chloride of barium, otherwise it contains sulphuric acid.

Magnesia sometimes contains alumina, the presence of which is detected as follows:—1. Saturate a small quantity of diluted sulphuric acid with the suspected magnesia, filter the solution, condense it to a small bulk by evaporation, and then test it with a concentrated solution of sulphate of potash. If alumina is present, a crystalline precipitate of alum will be produced after an hour's delay.—2. Dissolve the suspected magnesia in muriatic acid, filter the solution and supersaturate it with liquid ammonia. If the solution does not contain a considerable excess of acid before the addition of the ammonia, a quantity of muriate of ammonia must be added, or else a little more muriatic acid. If then the supersaturation of the solution by ammonia produces a white voluminous precipitate, this precipitate will consist of alumina. 3. Make a little of the suspected magnesia into a cake one-sixth of an inch in diameter by adding a drop of water. Heat it on charcoal before the blowpipe; then moisten it with a drop of a solution of nitrate of cobalt, and again strongly ignite it before the blowpipe. If the magnesia is pure, the cake will acquire a pale rose-red colour. If much alumina is present, the cake will acquire a blue colour.

Both carbonate of magnesia and calcined magnesia generally contain silica. Calcined magnesia is particularly liable to this contamination when prepared by adding caustic pot-

ash to sulphate of magnesia; because caustic potash is seldom free from silicate of potash. The presence of silica in either kind of magnesia can be detected by proceeding as follows:—Dissolve a quantity of the suspected magnesia in diluted muriatic acid and evaporate the mixture without previous filtration to dryness. Perform the operation in a Wedgewood's-ware basin over a lamp or a charcoal fire, and stir the mixture with a glass rod when it gets thick. Keep the mass hot till it forms a dry white powder. Let it cool, thoroughly moisten it with strong muriatic acid, allow it to repose for half an hour and then dilute it with water and filter it. If any insoluble powder remains, it is silica.

Magnesia, *Sulphate of. Epsom Salt.*—Sulphate of magnesia is found in commerce in the state of small white transparent four-sided crystals, which possess a saline bitter taste. This salt is sometimes contaminated by muriatic acid (which renders it liable to become moist in the air) and by lime. But these contaminations are now rare; for of late years the manufacture of sulphate of magnesia has been so much improved, that what is found in respectable shops is generally in a state of tolerable purity. A practice formerly much in vogue in England, and still existing in France, is the substitution of sulphate of soda for sulphate of magnesia. It is no uncommon thing in Paris to meet with the former salt under the name of *Epsom Salt of*

Lorraine, as if it was really a variety of sulphate of magnesia.

Another crystalised substance which is very frequently substituted for Epsom salt (and I am so charitable as to believe that the substitution is in all cases accidental), is oxalic acid. Once a month, or thereabout, the newspapers relate the fatal results of some case, in which death by poison is occasioned by the administering of oxalic acid in the place of Epsom salt. This mortality, one would think, is sufficient reason to induce people to learn how to take care of themselves. I shall presently present the means of effectually preventing *accidental* poisoning.

To Detect Muriatic Acid in Sulphate of Magnesia.—1. Heat the dry salt before the blowpipe with microcosmic salt on a copper wire, in the manner described at p. 59. By this process, a very small quantity of chlorine can be detected. 2. Dissolve the suspected salt in water, and test the solution with a solution of sulphate of silver. The production of a white curdy precipitate indicates the presence of muriatic acid (p. 58).

To Detect Lime in Sulphate of Magnesia.—Dissolve the salt in water, add a little muriate of ammonia to the solution, and then make it alcaline by adding ammonia. If the addition of ammonia causes a precipitate to be produced, add muriatic acid to re-dissolve the precipitate, and again make the solution alcaline by ammonia. When the solution is alca-

line and clear, test it with a solution either of oxalic acid, of oxalate of ammonia or of super-oxalate of potash. If lime is present, a white precipitate of oxalate of lime is produced.

To distinguish Sulphate of Soda from Sulphate of Magnesia.—1. Expose a morsel of the solid salt on a clean platinum wire to the extreme point of the blowpipe flame. Keep it there till the water of crystalisation has evaporated. If the salt contains soda it will then produce a long and brilliant yellow flame, but if it contains magnesia it will produce no coloured flame (p. 51).—2. Dissolve the salt in water, and add to the solution a small portion of a solution of carbonate of potash. If the salt contains soda, the solution remains clear; if it contains magnesia, an abundant white precipitate is produced.

To determine whether Sulphate of Magnesia is mixed with Sulphate of Soda.—The experiment consists of two processes; one to detect the magnesia, the other to detect the soda. The processes are those described in the preceding paragraph. If the solution of the salt gives no precipitate, while the solid salt produces a yellow flame, the sulphate contains soda without magnesia. If the solution gives a precipitate and the solid salt no flame, the sulphate contains magnesia without soda. If the solution affords a precipitate, and the solid salt a yellow flame, the sulphate contains both soda and magnesia.

To distinguish Epsom Salts from Oxalic Acid.—1. Put a crystal of the salt into your

mouth and taste it: Epsom salt is bitter, oxalic acid very sour.—2. When oxalic acid in crystals is dropped into water, it makes a crackling noise. This is not the case with crystals of Epsom salt.—3. The solution of oxalic acid changes all vegetable blue colours, such as that of litmus, to red. The solution of Epsom salt has no such power.

Caution respecting the use of Epsom Salt.—Dr. Christison records the following case of apparent poisoning with Epsom salt. "A boy ten years old took two ounces of this laxative partly dissolved, partly mixed in a teacupful of water; and had hardly swallowed it before he was observed to stagger and become unwell. In half an hour his whole frame was in a state of extreme debility, and in ten minutes more he died without vomiting or any other symptom of note. The circumstances having been investigated judicially, it appeared that the substance taken was pure Epsom salt; and that the father, who was dotingly fond of the child, gave the laxative on account of a trifling illness which he supposed might arise from worms." This case shows the impropriety of administering excessively large doses of this laxative.

MANGANESE, *Peroxide of.*—This substance is black and its crystals give a pure black streak upon unglazed porcelain. When it is pure, it gives no water on being heated in a little glass tube closed at one end. The hydrate of deutoxide of manganese, which also occurs native, is similar in appearance to

the peroxide of manganese. In commerce it is often mistaken for the latter substance, because, when in a crystalised state, it possesses the same black colour; but it is much inferior to the peroxide in value, being incompetent to produce either so much oxygen or so much chlorine as the latter. The hydrate of deutoxide is characterised by giving a brown streak upon unglazed porcelain, while the streak given by the peroxide is black. It is also distinguished from the peroxide by giving off water when heated over the spirit-lamp in a little glass tube closed at one end.

Peroxide of manganese is often found in commerce in the state of powder, and is then generally adulterated with charcoal, carbonate of lime and other foreign substances, particularly with peroxide of manganese which has already been made use of in the arts and of course is worthless. For this reason, peroxide of manganese ought always to be purchased in lumps. If the peroxide effervesces when thrown into diluted acids, it contains carbonate of lime. If it divides into two portions when merely shaken up with water, the one portion sinking below the liquid and the other rising to its surface, it contains charcoal. In this case, the substance which floats on the water must burn away before the blowpipe and exhibit the other properties of charcoal.—The following process detects the presence of such manganese as may have been already employed in the preparation of chlorine:

—Boil the manganese in water, filter the solution, and test it with solutions of nitrate of silver and chloride of barium. If these reagents produce white precipitates, it shows that the manganese is mixed with sulphates and chlorides, and that it has been previously employed in the preparation of chlorine, and afterwards been washed and again delivered to commerce.

MANNA.—Manna is a dried juice, procured from the flowering ash, which is cultivated for that purpose in Calabria. The best manna procured from that country is in oblong, light, and crumbly flakes of a whitish or pale yellow colour, and a somewhat transparent appearance. The inferior sorts are moist, unctuous, and of a darker colour. Manna is sometimes counterfeited by a composition of sugar and honey, mixed with a small portion of scammony.

MERCURY. *Quicksilver.*—Mercury must have a very fine, almost silver-white colour. It must readily form little round drops without tails or trains, and must be very liquid. When shaken in a bottle with common air, it must not become black, otherwise it contains lead or tin. When dissolved in nitric acid, the solution must not be milky, otherwise it contains tin. When the solution is evaporated to dryness, and the dry salt is ignited in a retort, it must be totally decomposed and volatilised. If it leaves a yellowish residue, which dissolves in nitric acid, it contains lead, or more rarely antimony. If the residue is insoluble in nitric

acid, but soluble in muriatic acid, and gives with the latter a solution which affords a yellow precipitate when tested with hydro-sulphuret of ammonia, the adulterant is tin. Almost all mercury contains a small portion of lead and tin.

MERCURY, *Red Oxide of. Red Precipitate.*—This compound is prepared by decomposing nitrate of mercury by heat. When pure, it is commonly crystaline, and then possesses a brick-red colour; but when it is very finely pulverised, it becomes yellowish. The red precipitate of commerce is found in the form of round, thin, flattened masses, or in irregular morsels. These masses are composed of a multitude of little micaceous scales, which adhere with a very slight force. The scales are sometimes sufficiently large and brilliant to be easily distinguished, and sometimes the morsels have an earthy fracture, and exhibit the scales very indistinctly. The latter sort is less esteemed than the preceding; its earthy appearance is a fault arising from defects in the mode of its preparation. The red precipitate turns black when gently heated, but the red colour returns as the heat is diminished. A strong heat decomposes it into oxygen gas and metallic mercury.—*Adulterants:* red precipitate often contains a little undecomposed nitrate of mercury, a compound which is carefully to be avoided in certain cases where the red precipitate is employed. The substances which are fraudulently added to pulverised red precipitate are red lead, peroxide of iron, brick-

dust, and cinnabar. It sometimes contains organic substances.

Detection of Adulterants in Red Precipitate. —1. Heat a small quantity of the suspected red precipitate over the spirit lamp in a glass tube closed at one end. The red precipitate will be decomposed, and will fly off in the state of oxygen gas and vaporised mercury. If *brick-dust* is present, it will remain in the tube unchanged. If *red lead* is present, the operation will yield fused protoxide of lead. If *peroxide of iron* is present, it will remain in the state of a dark red powder at the bottom of the tube. If *nitrate of mercury* is present, red fumes will be seen in the glass tube soon after the first application of the heat, and a very pungent odour will be perceived if the tube is held near the nose. If *vegetable substances* are present, the action of the heat will disengage a large quantity of carbonic acid, which can be detected by holding a piece of moistened litmus paper to the mouth of the tube; the presence of carbonic acid is detected if the litmus paper turns red and then becomes blue again upon being slightly warmed. If the red colour is persistant, it is due, not to carbonic acid, but to nitrous acid.—2. Mix the red precipitate with water. If it contains vegetable matter, the latter will remain suspended in the liquid, and may be decanted with it, whereas the red precipitate sinks instantly to the bottom of the water.—3. Heat the red precipitate on charcoal before the blowpipe, or throw it upon ignited coals; if

it burns with a blue flame, and gives the smell of sulphurous acid, the presence of cinnabar is detected.

Golden Ointment.—A valuable ointment, used in domestic medicine to cure styes on the eyelids. It is prepared by mixing pure hogs' lard with pure red oxide of mercury, which must be quite free from nitric acid, and be very finely pulverised. It should be kept in small portions. When it appears very pale, it is owing to the presence of too small a proportion of the red oxide or to the rancidity of the fat. The ointment must not redden litmus paper, otherwise it is unfit for use.

MERCURY, *Sulphurets of.* (*a*) *Black Sulphuret, Ethiops Mineral.*—This is stated to be adulterated with ivory-black. *Detection:*—Expose it to a red heat in an earthen crucible: the sulphuret will fly off in vapour; the ivory-black will be burnt into a white powder, which consists of phosphate of lime.—It sometimes contains sulphuret of antimony. To detect this, boil a little of the suspected article in strong muriatic acid, pour the clear solution into water: if antimony is present, a white precipitate will be produced.—It must exhibit no globules of mercury when examined with a magnifying glass.

(*b*) *Red Sulphuret. Vermilion. Cinnabar.* —This compound is subject to be adulterated by red lead, chalk, and dragon's blood. There are moreover several varieties of vermilion to be met with in commerce; the best is termed Chinese vermilion, and is found in little packets

of about an ounce and a half each, enclosed in shining black papers. Those who would have vermilion in a state of purity, should purchase it in a crystaline mass and pulverise it themselves. *Detection of red lead.*—1. Throw a little of the suspected vermilion into nitric acid. If the vermilion is pure it will retain its brilliant red colour; if it contains red lead, the acid will turn it brown.—2. Put a little of the suspected vermilion into a clean iron spoon and expose it to heat. If the vermilion is pure it will volatilise without residue; if it contains red lead, it will leave in the spoon a brown powder composed of oxide and sulphuret of lead. *Detection of chalk:*—Mix the suspected vermilion with a little water, and then add a few drops of nitric acid. If any chalk is present, an effervescence will be produced. Filter the solution, neutralise it with ammonia, and add a solution of oxalic acid or of superoxalate of potash. If a white precipitate is produced, it is confirmatory of the presence of chalk. *Detection of dragon's blood:*—1. Digest the suspected vermilion in spirits of wine. If dragon's blood be present, the solution will appear red.—2. Dragon's blood is left unvolatilised when the vermilion is exposed to heat.

MERCURY, *Protochloride of. Calomel.*—This compound is apt to contain corrosive sublimate, in consequence of the careless manner in which it is sometimes prepared: it occasionally contains other white powders.—1. Put a little into a glass tube, close the latter with the finger, and heat it over a lamp. If

a portion of the calomel does not sublime, it is adulterated.—2. Boil one part of calomel with ten parts of distilled water and a very small quantity of sal ammoniac. Filter the solution through paper, and add a solution of carbonate of potash to the clear liquor. If a white precipitate is produced, it proves the calomel to contain corrosive sublimate.—3. Gently heat one part of calomel with four parts of rectified alcohol. Filter the solution, dilute it with water, and add to it a solution of lime in water. If a yellow precipitate is produced, it indicates the presence of corrosive sublimate.—4. If calomel appears gray instead of white, heat it in a glass tube with nitric acid. If red fumes are produced, the calomel contains metallic mercury in a state of mixture.—Calomel should be kept in glasses coated with black paper, because it turns brown when exposed to too strong a light. When pure it forms a perfectly white crystaline mass, which becomes yellowish when pulverised.

Mercury, *Perchloride of. Corrosive Sublimate.*—It is found in white crystaline masses, which are joined together so as to assume a more or less perfectly cubical form. It must dissolve completely in from 16 to 20 parts of water. If it leaves a white residue, it probably contains calomel. The solution must be colourless. Corrosive sublimate must also dissolve completely in alcohol. It must volatilise without residue when heated, otherwise it contains foreign substances. When moistened with a solution of potash, it must turn yellow; if it

turns black, it contains calomel. When moistened with ammonia, it must remain white; if it turns black, it contains calomel.

MERCURY, *White Precipitate of.*—This preparation is liable to be adulterated with white lead or chalk. Ignite the suspected article strongly in a crucible: if nothing remains unvolatilised, the substance is pure. If there is any residuum, dissolve it in nitric acid, and add liquid ammonia to the solution. If a precipitate is formed, separate it by filtration, and moisten it with liquid sulphuretted hydrogen; it will turn black if lead is present. Add to the filtered liquor a solution of superoxalate of potash; the production of a white precipitate indicates the presence of lime.

MERCURY, *Protonitrate of,* in solution.—It must be perfectly colourless, and capable of mixing with water in all proportions without suffering decomposition. A solution of chloride of sodium must precipitate the mercury completely, and the filtered solution must give no precipitate with liquid sulphuretted hydrogen or solution of chloride of tin, otherwise it contains pernitrate of mercury.

MERCURY, *Pernitrate of,* in solution.—It must be perfectly colourless. When neutral, it gives a precipitate on being mixed with water, but it can be diluted after being rendered slightly acid. When properly concentrated, it crystalises in needles, which are converted by boiling water into a yellow subsalt. The solution gives, with a solution of potash, a yellow precipitate, with ammonia a

white precipitate. It must afford no precipitate with a slight excess of muriatic acid, or with a solution of chloride of sodium, otherwise it contains protonitrate of mercury.

MERCURIAL OINTMENTS.—They must be uniformly mixed, and free from spots of black and white. When the mercury is properly divided, the ointments possess a dull green colour. When rubbed upon paper, the eye, even when assisted by a magnifying glass, must not be able to detect globules of metallic mercury. The ointments must not be black, otherwise they are adulterated with sulphur or lamp-black. Sulphur is added by the preparer, to facilitate the admixture of the mercury with the fat, but it produces sulphuret of mercury in the ointment. Lamp-black is added to cloak a deficiency of mercury. Sometimes the ointment is wholly free from mercury. This cheat may be detected by melting the ointment, or by warming it in very strong alcohol, or in ether, which dissolve the fat, and deposit the mercury if present, or demonstrate its deficiency when absent.

MILK.—In large towns, where the consumption of milk is very considerable, there is very little exposed to sale without previously receiving some fraudulent addition. In most cases, the substances which are added are by no means injurious to the health of the individuals who drink the milk; but they do not the less diminish those good qualities which render milk so extremely valuable as an aliment.—The best milk is of a mean con-

sistence. Its specific gravity is about 1·0324, that of water being 1·0000. It should have a dull white colour, and a soft, agreeable, sweetish taste. The adulterant which is most frequently added to milk, and which is the most difficult of detection, is water. Milk which has been diluted with water always presents a bluish colour, instead of that dull white which is the characteristic of pure milk. It has also a watery taste, and is found to yield, after three or four hours' exposure to the air, a much smaller proportion of cream than is produced by a similar quantity of pure milk.

Several attempts have been made to contrive *lactometers,* or instruments for ascertaining the comparative goodness of samples of milk. One of these lactometers was similar in principle to the hydrometer. It consisted of a graduated glass tube and a bulb. When plunged into milk it took a higher or lower position, according to the assumed goodness of the milk. But this instrument was far from possessing a desirable degree of certainty in its indications. The difference of temperature in various cows, the greater or less abundance of the animal's food, and its age and state of health have all great influence on the specific gravity of the milk produced.—A *lactometer* of a better description consists of a glass tube about a foot long and half an inch in diameter; tubes of which size, supported by a foot, can be bought at the glass houses for eighteenpence. If milk is poured into a tube of this kind, and permitted to repose there, the cream which it contains

rises to the surface and forms a cake, the bulk of which, compared with the bulk of the milk, denotes the comparative goodness of the milk. The lactometer tube should be graduated into ten parts, and the two upper parts divided each into ten others. It is then easy to ascertain at a glance the *per centage* of cream contained in any sample of milk submitted to trial. For the sake of obtaining a *standard*, it should be ascertained by direct experiments, how many parts of cream are contained in 100 parts of genuine new milk.

The bluish colour and the thin appearance produced in milk by dilution with water, are sometimes hidden by the addition of flour and yolk of eggs, which not only correct the colour, but give more consistence to the mixture. The presence of the flour can be detected by means of iodine, in the manner described in the article on "Cream" (p. 148).

Another substance which is occasionally employed to give a good colour to diluted milk, is the colouring drug anatto. There is no reason to imagine that the addition of chalk to milk is much practised, because chalk has the property of subsiding too rapidly to answer the intended purpose. I have indeed frequently observed insoluble residues at the bottom of milk-pots in which pennyworths of milk had been taken from ambulating retailers, but I never submitted these residues to analysis.

The practice of putting milk into vessels of lead to make it throw up cream with greater

readiness, is highly reprehensible; because greasy liquids are capable of dissolving lead with facility (p. 14), and milk impregnated with lead is poisonous. The presence of lead in milk can be detected by the processes described at p. 10.

Muriatic Acid.—Pure muriatic acid forms a colourless liquid, which gives out white fumes when in a state of concentration. If it possesses a yellow colour, it arises from impurities; it may be due to chloride of iron, nitrous acid, or chlorine. The presence of iron is detected by neutralisation with ammonia, which precipitates the iron in the state of brown flocks, as hydrate of peroxide. When the colour is due to nitrous acid, the neutralisation of the muriatic acid by ammonia removes the colour without producing a precipitate. Muriatic acid which is coloured by nitrous acid, is not rendered colourless by heat, but has the property of dissolving gold leaf. When muriatic acid contains chlorine, it is deprived of its yellow colour by heat, by exposure to light, and by neutralisation with ammonia. In the two last cases, the muriatic acid has also a peculiar odour.

When muriatic acid leaves a residue after evaporation, it denotes the presence of sulphate of soda, chloride of sodium, or chloride of iron. Diluted with water and tested with a solution of chloride of barium, the muriatic acid must remain untroubled, otherwise it contains sulphuric acid. It must not have the power of dissolving gold leaf, even when heated, other-

wise it contains chlorine or nitrous acid. When supersaturated with barytes' water, it should give no white precipitate, otherwise it contains sulphuric or sulphurous acid. If the white precipitate, on being washed with water and moistened with sulphuric acid, disengages the odour of sulphurous acid, the muriatic acid contains sulphurous acid.

Concentrated muriatic acid has a specific gravity of 1·21. The muriatic acid of commerce has in general a specific gravity of 1·16 or 1·17. If heavier than this, it often contains salts; if lighter, it is diluted with water.

Mushrooms.—A great number of *fungi* of a poisonous nature, bear a near resemblance to the mild eatable mushroom, so that even the best judges of them are liable to occasional deception. The following description of the true mushroom may be useful to those who intend to gather or to purchase this vegetable. The *gills* or under part of the cap are loose, of a *pinky-red*, changing to a liver colour; situated close to the stem but not united to it; very thick set, irregularly disposed, some forked next the stem, some next the edge of the cap, and some at both ends, in which case the intermediate smaller gills are generally excluded. The *cap* or pileus is externally white, changing to brown when old, and becoming scurfy; it is regularly convex, fleshy, flatter when old, from two to four inches, but sometimes even nine inches in diameter; it liquifies as it decays; the flesh is white. The *stem* is solid, white, cylindrical, from two to

three inches high, half an inch in diameter. The *curtain* or membrane which extends from the stem to the edge of the cap, is white and delicate. When the mushroom first makes its appearance, it is smooth and almost globular, and in this state it is called a button. This species is esteemed the best and most savoury, and is much in request for the table. It is eaten fresh, either stewed or broiled, or preserved as a pickle, or in powder: it also furnishes the sauce called ketchup. The field plants are better for eating than those raised in artificial beds, their flesh being more tender; but the cultivated mushrooms are better-looking, may be more easily collected in the proper state for eating, and are firmer and better for pickling. The wild mushrooms are found in parks and other pastures where the turf has not been ploughed up for many years. The best time for gathering them is in August and September.

Those who are accustomed to mushrooms, can distinguish the true from the false *by the smell.* The following test will be found useful to other persons :—Sprinkle salt on the spongy part or gills of the mushrooms to be tried. If they turn yellow, they are poisonous; if they turn black, they are good. Allow the salt to act a little time before you decide as to the colour.

Characters of False Mushrooms or Poisonous Fungi.—They have a warty cap, or else fragments of membrane adhering to the upper surface; they are heavy, they emerge from a

vulva or bag; they grow in woods and shady places, or in tufts or clusters on the trunks or stumps of trees; they have an astringent styptic taste and a pungent and often nauseous odour; they become blue after being cut; they are moist on the surface; they possess an orange or rose-red colour, they turn yellow when salted.—Mushrooms which possess any of these properties, are to be shunned as dangerous.

Mustard.—The mustard which is grown in various countries differs considerably in the strength and appearance of the seed it produces. It often happens that the seed which produces the most beautiful yellow powder is not that which possesses the most burning taste, or which has the greatest tendency to act powerfully when applied to the skin as a blister. The strongest mustard gives a powder which has a greenish-yellow colour, but which is intermingled with black points arising from the presence of the pulverised shell of the seed. The pale yellow and weak mustard-powder often loses its colour after being pounded some time. *Clever* merchants then give it a factitious colour, by means of turmeric. It is easy to know when the yellow colour of mustard is owing to turmeric, because the addition of a few drops of a solution of potash or ammonia, changes the yellow colour of turmeric to brown, while it has no action on the colour of mustard.

The *patent mustard* which is sold in pots by the oilmen of London, is a mixture of

ground mustard-seed and water, with a few other ingredients added principally to make the mixture keep well. The proportions are as follow. Mustard flour eight pounds, wheaten flour (added to increase the bulk of the mixture) one pound and a half, bay salt one pound and a half, Cayenne pepper two ounces and a half, water, a sufficient quantity. Mustard prepared without salt or Cayenne pepper, speedily becomes sour in hot weather, as is well known to every gourmand of taste.

The bright yellow powder sold under the name of *flour of mustard,* is generally a compound of black and pale mustard-seed, Cayenne pepper, wheat-flour, and turmeric.

Essence of Mustard.—The stimulating application sold under the name of *Whitehead's Essence of Mustard,* is composed of camphor and oil of rosemary, dissolved in oil of turpentine, with a little flour of mustard added to it.

Nitric Acid.—Nitric acid is perfectly colourless when pure; but it commonly contains nitrous gas, which gives it a yellow colour. Such acid becomes colourless when diluted with water. *Aqua fortis* is weak and impure nitric acid.

Nitric acid must not leave the smallest residue when evaporated to dryness on a watch glass. If it contains nitrate of potash, or oxalic acid, these bodies will remain in the watch glass. It must give no precipitate with a solution of nitrate of silver, otherwise it contains muriatic acid. After considerable dilution with water, it must give no precipi-

tate with a solution of chloride of barium or of nitrate of barytes, otherwise it contains sulphuric acid. If it is found to contain sulphuric acid, it must be tested with a solution of sulphate of silver. If it gives no precipitate, it contains no muriatic acid. Neutralised with ammonia and tested with hydrosulphuret of ammonia or with liquid sulphuretted hydrogen, it should give no precipitate, otherwise it contains a metal.

The nitric acid of commerce has generally a specific gravity of 1·31. By careful preparation it may be obtained of the specific gravity of 1·51. When the nitric acid of commerce is lighter than 1·31, it is diluted with water; when it is heavier, it generally contains saltpetre or sulphuric acid.

Nitric Ether.—A liquid of a faint yellowish colour. Its specific gravity is 0·785. It must not redden litmus paper. It must be extremely inflammable, must give out nitrous acid during its combustion, and must leave no residue. When agitated with water, it must not diminish in volume.

Sweet Spirit of Nitre.—This is a solution of nitric ether in alcohol. It must be preserved in very small bottles closed with glass stoppers, each completely filled with the preparation. It is very improper to attempt to prevent its becoming acid, by permitting it to stand over carbonate of potash, magnesia, or lime. These alcaline substances frequently decompose the spirit, and produce nitrates of the different bases, which then dissolve in the

spirit. This is particularly the case with magnesia or lime. The spirit of nitre which has been spoiled thus, leaves a saline mass upon being evaporated. When the preparation is good, it forms a perfectly colourless solution, possessing a peculiar odour and a specific gravity of 0·850. It must redden litmus paper very feebly, and volatilise without leaving the least residue. When diluted with a sufficient quantity of water, it must give no precipitate with a solution of nitrate of silver, otherwise it contains muriatic acid, nor with a solution of chloride of barium, otherwise it contains sulphuric acid.

Ointments.—Examine them as to the state of the fat which they contain. It ought not to be acid, nor rancid, nor possess an ill smell.

Olive Oil. *Florence Oil. Salad Oil.*—Olive oil is obtained from the fleshy part of the olive, the fruit of *olea Europea.* Its colour is greenish-yellow or pale yellow. Its specific gravity is 0·92. It begins to deposit white grains of stearine before it is cooled so low as the freezing point of water, and this deposition occurs sooner and more abundantly in the hot-pressed than in the cold-pressed oil.

Three sorts of olive oil occur in commerce. The best or virgin oil is obtained by a slight cold-pressing. The usual sort is gained by a strong pressure, assisted by heat, operated upon the substance which has already undergone cold-pressing. The worst sort is gained by boiling the pressed cakes in water, and

skimming off the oil from the liquor. Olive oil is more employed than any other vegetable oil, and being dear, is often adulterated. That which is used for food is frequently mixed with poppy oil, and that employed for burning is mixed with rape oil. It is of importance to be able to detect these adulterations. The following process is grounded on the fact that olive oil becomes solid when mixed in certain proportions with acid protonitrate of mercury, while the oils expressed from seeds do not exhibit the same phenomenon. Six parts of mercury are dissolved in seven and a half parts by weight of nitric acid of the specific gravity of 1·35, without the aid of heat. Two parts of this solution are mixed with twelve parts of the oil which is to be examined, in a glass tube which must be frequently shaken. The mixture soon thickens and by the following day, if the oil be pure, becomes so hard that a glass rod cannot be put into it without the application of some degree of force. But if the oil contains a tenth part of foreign oil, the paste which is formed is not thick enough to present any opposition to the dropping in of a glass rod. The greater the adulteration, the thinner the resulting mixture. The amount of foreign oil contained in the olive oil is therefore judged of by the quantity of oil which remains liquid after the operation. The temperature of 68 deg., is that at which the operation succeeds best; because at that degree of heat, the oil and coagulum best separate.

Olive oil is much longer in becoming viscous than any other oil. On this account, it is made use of by watch-makers, after having undergone a purification which is performed as follows:—A bottle is filled with olive oil, a bar of lead is placed in the middle of it, the bottle is corked and then placed in a window exposed to the direct rays of the sun. The oil gradually becomes covered with a cheesy mass, which partly falls to the bottom, while the oil is deprived of its colour and rendered as clear as water. When the lead ceases to produce any more of the white substance, the clear and colourless oil is poured off and preserved for use.

Olive oil is frequently contaminated with lead. It is a practice in Spain to suffer the oil to repose in leaden cisterns till it becomes clear, before it is offered for sale; and in this country, the oil is sometimes kept in leaden or pewter cisterns to preserve it from rancidity. The presence of lead in olive oil may be detected by the processes described in the article on lead at p. 8.

Opium.—*Turkey Opium* is found in the European market in flattish cakes, sprinkled with pieces of dried leaves and with the seed capsules of certain species of rumex; the latter character is considered an indication of its goodness, as the inferior sorts of opium have none of these capsules adhering to them. It should be of a rich reddish-brown or fawn colour, a tough consistence, and a tolerably compact and uniform texture. Though tena-

cious when soft, it hardens when long exposed to the air, breaks then with a uniform shining surface, and affords a yellowish-brown powder. This can be again aggregated by a heat so low as that of the hand. It has a peculiar strong, heavy, narcotic odour, which is not empyreumatic when the drug is pure. Its taste is nauseously bitter, and sufficiently warm and acrid to bite the tongue and lips, or even to blister them if kept in contact too long.

East Indian Opium is a very inferior article to the opium which is imported from Turkey. It is in round masses, covered with the petals of the poppy, in successive layers, to the thickness nearly of one-fourth of an inch. It has a strong empyreumatic smell, but not much of the peculiar, narcotic, heavy odour of the Turkey opium. Its taste is more bitter, equally nauseous, but less acrid. Its colour is blacker; its texture less plastic but more friable. It is more soluble in boiling water, when triturated with which, it leaves no insoluble plastic residuum as Turkey rhubarb does.

Adulterants of Opium. Extract procured by boiling the poppy, cow-dung, oil of sesamum, the ashes and dried leaves of the plant, aqueous extract of poppy heads, extracts of Chelidonium glaucum, Lactuca virosa, and Glycyrrhiza glabra; also, gum arabic, tragacanth, aloes, and many other articles. Bullets are sometimes concealed even in masses of the best opium.

Characteristics of bad Opium. Opium is

regarded as bad when it is either very soft, greasy, light, friable, of an intensely black colour, mixed with herbaceous substances, or exhibiting dark brown or black patches of extract. A weak or empyreumatic odour, a slightly bitter, acrid, or sweetish taste, and the power of marking a brown or black continuous streak when drawn across paper, are also symptoms of inferior opium. The aqueous solutions of both kinds of opium are transparent when filtered, that of the East Indian opium having the deepest brown colour. The solution of acetate of barytes produces no precipitate in the solution of Turkey opium, but forms a copious precipitate in the solution of East Indian opium.

Orange-Flower Water.—It ought not to redden litmus paper, nor taste acid, otherwise it contains free acetic acid. It ought not to become blue when mixed with liquid ammonia, otherwise it contains copper.

Oxalic Acid.—It often contains a little nitric acid. This gives it a yellowish colour, a nitrous odour, and the property of corroding the corks and paper with which it comes into contact. The presence of nitric acid may be detected by the processes described at p. 56.

Palm Oil.—It should have the consistence of butter, an orange-yellow colour, a soft taste and an odour like that of the violet. It is imitated by lard or tallow, coloured by turmeric and perfumed with Florence iris. An alcaline solution turns the false palm oil red, but does not change the colour of pure palm oil.

Parsley.—An umbelliferous plant of great activity, which bears a near resemblance to parsley, is Fool's parsley or *Æthusa cynapium*. It has been the occasion of several fatal accidents. Fool's parsley is at once distinguished from true parsley, by the leaves being black and glistening on the lower surface, and by the nauseous odour they omit on being rubbed.

Parsnips.—See article "Beer," p. 103.— Several fatal accidents have arisen from individuals mistaking the root of henbane (a deadly poison) for that of parsnip, to which it bears a considerable resemblance.

Pepper.—*Black Pepper* is the fruit of a creeping plant which grows in the East Indies. It has the form of small blackish grains, which have a corrugated surface, an aromatic odour, and a hot, biting, irritating taste. They are internally white. The powder powerfully excites coughing and sneezing. Pepper-corns have been imitated by a great number of artists. The artificial product is a paste composed of a small quantity of true pepper-dust, mixed with ground mustard-seed and various other native piquant and biting plants; the whole being made into a cohesive mass by means of mucilage. In some cases, factitious pepper has been found to contain oil-cakes and common clay, combined with a portion of inferior pepper, called in the trade P. D. or pepper dust, or D. P. D. or dirt of pepper dust; these articles consisting either of spoiled pepper or of the sweepings of the pepper warehouses. The ingredients of the factitious

pepper are first made into a mass by means of mucilage, and the mass is then granulated by being forced through a sieve and afterwards rolled in a cask. So cleverly is this managed that the granulation is extremely regular, and the artificial pepper-corns, after having been mixed with the native pepper, can scarcely be discriminated by an unpractised eye. The manufacture of spurious pepper is carried even to a pitch of refinement, so much so, indeed, that to render its resemblance to true pepper more exact, the manufacturers often introduce a mustard-seed into the interior of each little mass of paste which is destined to become a pepper-corn. When the pepper is finished, the mustard-seed within it occupies a hollow cavity, because the paste shrinks as it dries and gives the imprisoned mustard-seed a little liberty. If a grain of this factitious pepper is broken for examination, the mustard-seed immediately falls out and leaves in the pepper-corn a hollow precisely similar to that which is frequently to be seen in the centre of the grains of true pepper. This ingenious manufacture does not pay well, and is therefore not carried on, when East Indian pepper bears a moderate price. True pepper can be distinguished from factitious pepper by the difference in its taste. It can also be readily distinguished by letting a small quantity of it macerate in warm water. True pepper then preserves its spherical form and its solid consistence, while factitious pepper swells up, soon becomes soft and sticky, and falls to

pieces on experiencing the least degree of agitation.

Ground Black Pepper. This is adulterated by the addition of the rubbish above alluded to under the technical names of P. D. and D.P. D., and sometimes by powdered hemp-seed and by ivory black. The latter may be separated by mixing the suspected pepper with water, and pouring off the pepper with the water when the ivory black has sunk to the bottom in consequence of its superior specific gravity. But as the detection of vegetable adulterants in ground pepper, is in most cases an impossibility, the only method of being sure of getting good pepper is to buy it whole and grind it yourself. The mill of the grocer should be avoided in every possible case. I have shown the necessity of this, in speaking of the adulteration of coffee.

White Pepper.—When black pepper is steeped during several days in sea water exposed to the heat of the sun, the rind or outer bark becomes so loose that if the pepper is taken out of the steep and dried, the rind may be rubbed off with the hands. White pepper is simply black pepper which has undergone this operation. It is always inferior to black pepper both in strength and aromatic flavour, because a portion of the oil and resin in which its virtues reside, are lost with the black bark of which this operation deprives it. Consequently white pepper is inferior in quality to black pepper though sold at a higher price. The white pepper is imitated by fraudulent

manufacturers with greater facility than the black pepper, because its surface is smooth and its colour easy to imitate. Spurious white pepper may be distinguished from the true kind by the method which I have given above for the detection of spurious black pepper. It has been said that certain dealers were in the habit of giving a brilliant whiteness and a considerable degree of weight to their white pepper, by rolling them in gum or starch-water holding carbonate of lead in suspension; but this most dangerous species of adulteration could hardly have been practised for any length of time, for pepper coated with this mineral, would speedily blacken on exposure to air, or to the slightest sulphurous or fetid exhalation. It would be easy to have direct experimental proof of the presence of lead, in case of the occurrence of this adulteration; for the pepper would instantly turn black on being moistened with liquid sulphuretted hydrogen.

Peruvian Bark.—The disease for which bark was introduced into medical practice, is intermittent fever, and there is still no remedy which equals it in power. It is also regarded as one of the most valuable remedies in certain forms of continued fever. Its virtue has recently been found to reside in a substance which bears a very small proportion in bulk and weight to the bark from which it is extracted. This substance is *quinine*. United to sulphuric acid, it forms a most excellent medicine, in which all the properties of the

Peruvian bark are concentrated. The sulphate of quinine is most generally administered in the form of pills, one of which has the same effect on the human body as a large mass of the bark in substance. The different sorts of bark differ considerably in the proportion of quinine which they are capable of affording. There is no other method of ascertaining the goodness of a particular specimen of bark than that of extracting the quinine and weighing it. But this requires an operation too tedious for any to perform but such as deal largely in bark. Those who buy it retail, must trust to the honour of their druggist. Nevertheless I subjoin a description of the principal varieties of Peruvian bark.

The *pale* or common Peruvian bark of the shops, is furnished by the *Cinchona lancifolia*. It is imported in chests of about 200 pounds weight. Its form is rolled-up pieces or quills of various dimensions, mixed with larger and flatter pieces. The small and fine quills bear the highest price. They are called *crown bark*. The larger quills constitute a second commercial variety; while the flat, coarse, and broken pieces are the least esteemed. This bark is covered with a gray skin, which has numerous transverse fissures, and is more or less coarse according to the size of the quills. It generally abounds in lichens. Its internal colour is deep cinnamon. When fresh and in large parcels, it has a peculiar and slightly aromatic odour, which should be free from all odour of other drugs and from mustiness. Its

taste is austere and bitter. Its fracture is short and dense.

Yellow Bark is the produce of the *Cinchona cordifolia*. It is found in the shops chiefly in flat pieces, and in large rolls or quills eight or ten inches long. Its external epidermis is brown and thick; its internal colour is orange-brown. It resembles the pale bark in odour, but is more bitter in taste and scarcely at all astringent. This species of bark has always been considered as inferior to the preceding.

Red Bark is the product of the *Cinchona oblongifolia*. It occurs in flat and quilled pieces, covered with a reddish-brown epidermis; its texture is fibrous, and its internal colour a rusty red. It is more astringent and less bitter than the yellow bark; but is without the peculiar aromatic austerity of the pale bark. This kind is not much used in medicine.

The bark exposed for sale in the shops is sometimes found to be in a state of complete inertness, its quinine having been previously extracted by the chemical cunning of those through whose hands it has passed. Peruvian bark in powder is frequently adulterated with oak and mahogany saw-dust. This constitutes a delectable compound to be mixed with port wine and administered to a sick man. The difficulty of detecting this adulteration is sufficient to induce reasonable people to prefer the quinine pills to the bark in powder.

But, then, the sulphate of quinine is itself liable to adulteration. The analysis of various

specimens of this drug has detected sulphate of lime, tallow, sugar, and sulphate of cinchona.

Sulphate of Lime. This substance remains behind when the sulphate of quinine is calcined in the open air. *Stearine* (tallow). Treat the suspected sulphate of quinine with water acidulated by sulphuric acid. This dissolves the sulphate of quinine but not the stearine. If the mixture is heated, the stearine swims on the surface of the liquor, and forms little transparent drops which become opaque when the liquor cools. *Powdered Sugar.* Dissolve the sulphate of quinine in water, mix the solution with a sufficient quantity of a solution of carbonate of potash to precipitate the whole of the quinine; filter the solution and evaporate it to dryness. It contains the sugar mixed with a small quantity of sulphate of potash. The sugar may be separated from this salt by means of alcohol. *Sulphate of Cinchona.* Dissolve the sulphate of quinine in hot water acidulated with sulphuric acid; evaporate the liquor and permit the sulphate of quinine to crystalise; then evaporate the liquor again, to crystalise the remainder of the sulphate of quinine. When no more crystals can be obtained, neutralise the liquor with carbonate of potash, gather the precipitate on a filter, wash it with alcohol and evaporate the alcohol employed in the washing. If it furnishes crystals which have a bitter taste, are insoluble in cold water, but soluble in alcohol, the sulphate of quinine contains sulphate of cinchona.

Phosphoric Acid.—It should dissolve completely in water. If it leaves a residue, it intimates the presence of silica and alumina.—The solution should continue transparent, when neutralised by ammonia or caustic potash. If a precipitate appears, which does not redissolve in caustic potash, the phosphoric acid contains acid phosphate of lime. If the precipitate dissolves in an excess of potash, the acid contains silica or alumina. The solution should give no precipitate with a solution of chloride of barium, otherwise the phosphoric acid contains sulphuric acid. The solution should give no precipitate with a solution of nitrate of silver, otherwise it contains muriatic acid. Metallic mercury must not be attacked even when boiled with the solution, otherwise the phosphoric acid contains nitric acid. In this case, a feather dipped into it becomes yellow on exposure to the air.—When the solution is treated with sulphuretted hydrogen gas, it must give no black precipitate, otherwise it contains copper, lead, or tin.—When supersaturated with caustic potash, it must not give out the odour of ammonia, nor produce white clouds when a rod moistened with muriatic acid is held near it, otherwise it contains phosphate of ammonia.—When the phosphoric acid is shaken with red oxide of mercury, and then left to repose some time, the mixture must not exhibit globules of metallic murcury, otherwise the phosphoric acid contains phosphorous acid.

Pickles.—It was at one time a pretty

general custom to adulterate pickles with copper. In many old cookery books, the cook is plainly directed to make her pickles in a copper pan, or to put halfpence among them, that they may acquire a fine green colour. Copper was found by DR. FALCONER in so large a quantity in some pickled cucumbers, bought at a great London grocer's, that the pickles had even the peculiar taste and smell of copper. DR. PERCIVAL analysed some pickled camphire, the eating of two small platefuls of which caused the death of a young lady, and found it to be strongly impregnated with copper. As pickles are a great article of commerce, being sold in vast quantities to merchants and seamen, and as their commercial value is affected very considerably by their appearance, there is a great temptation to give to them their much-admired fresh and lively green colour by the addition of copper, notwithstanding the danger which attends the eating of such pickles. It is fortunate, therefore, that the detection of copper in pickles can be effected by processes which are extremely easy of performance. (See the article on the "Detection of Copper," page 2.)

POTASH.—Caustic potash, pure potash, or hydrate of potash, ought to be quite free from carbonic acid. It generally, however, contains a small quantity of that acid, which may easily be detected by adding lime water to a solution of the potash, which immediately troubles it if lime is present. If the solution effervesces upon the addition of sulphuric acid, it contains

carbonic acid in considerable quantity. The solution of potash must give no precipitate with a solution of muriate of ammonia, otherwise it contains silica or alumina. It must give no precipitate with a solution of carbonate of potash, otherwise it contains lime. After neutralisation with nitric acid, it must give no precipitate with a solution of nitrate of silver, otherwise it contains muriatic acid; nor with a solution of chloride of barium, otherwise it contains sulphuric acid.

Fused Potash must dissolve in water without leaving brown flocks, otherwise it contains peroxide of iron. The solution must be colourless and act towards re-agents as above mentioned.

Potash, *Acetate of*.—The crystals should be perfectly colourless. If it is gray or black, it is partly decomposed; if yellow, it contains iron; if green, copper.—It deliquesces in the air; it dissolves in an equal weight of water; if it does not readily and completely dissolve in two parts of water, it is impure. If it does not wholly dissolve in alcohol, it contains sulphate or supertartrate of potash. Its solution must not give a blue precipitate with a solution of yellow prussiate of potash, otherwise it contains iron; nor a red precipitate, otherwise it contains copper. It must not be blackened by liquid sulphuretted hydrogen, otherwise it contains lead; nor give a white precipitate, otherwise it contains zinc. It must give no white precipitate with a solution of nitrate of silver, otherwise it contains muriatic acid; nor

with a solution of chloride of barium, otherwise it contains sulphuric acid. It ought not to have an empyreumatic odour, otherwise it contains pyro-acetate of potash.

Potash, *Subcarbonate of. Crude Potash.*—The potash of commerce is in irregular lumps of very variable colours, such as white, gray, blue, green, and red. The principal sorts come from America, Russia, Tuscany, and Dantzic. It consists principally of subcarbonate of potash, mixed with sulphuret of potassium, chloride of potassium, sulphate of potash, silica, alumina, oxides of iron and manganese, and other heterogeneous substances. The value of a sample of potash depends upon the quantity of the carbonate of potash which it contains. The above-named impurities lessen its value, but give it no injurious properties, excepting the sulphate of potassium, which is a very mischievous article in a bleach-tub.—In the analysis of potash, the carbonate of potash is decomposed by diluted sulphuric acid. The strength of the test acid is ascertained by previous experiments, and it being ascertained how much of the test acid is necessary to saturate a given weight of the impure potash, the equivalent quantity of pure carbonate of potash is readily ascertained by calculation. I do not give the details of the operation, because it would require too much space to do justice to it.—*Pearlash* is a half-purified subcarbonate of potash. Though deprived of the colouring matters, and of a variety of other impurities which accompany crude potash, it

still retains sulphate of potash and other inert salts in considerable quantity.

Potash, *Subcarbonate of.*—It must be quite white, otherwise it contains charcoal and other substances. It must dissolve completely in water, and produce a colourless solution. When the solution is neutralised by nitric acid, it must not produce a white precipitate, otherwise it contains silica. The neutralised solution must give no precipitate with a solution of nitrate of barytes, otherwise it contains sulphuric acid; nor with a solution of nitrate of silver, otherwise it contains muriatic acid. It is very rare that subcarbonate of potash is obtained in such a state of purity as not to be slightly affected by the two last-named re-agents. The neutralised solution must give no precipitate with hydrosulphuret of ammonia, otherwise it contains copper or iron.

Potash, *Bicarbonate of.*—This salt forms colourless crystals, which effloresce in the air and lose water and carbonic acid. They dissolve completely in about six parts of water. The solution must not turn turmeric paper brown, otherwise it contains subcarbonate of potash. When the salt is quite neutral, it is sure to contain no silica. The solution, after neutralisation by nitric acid, should behave towards re-agents exactly like a neutralised solution of subcarbonate of potash.

Potash, *Chlorate of.*—The crystals have the form of scales, or four or six-sided tables, and are quite white, bearing much resemblance to boracic acid. If thrown on hot coals it de-

flagrates like saltpetre. It dissolves completely in water. The solution must give no precipitate with a solution of nitrate of silver, otherwise it contains chloride of potassium; nor with a solution of chloride of barium, otherwise it contains sulphate of potash.

If you wish to know whether the chlorate of potash is sufficiently pure to make *prometheans,* or chemical matches, mix two parts of the salt in fine powder with one part of pounded lump-sugar, and touch the mixture with a drop of oil of vitrol. If it instantly inflames, the salt is good enough for the purpose.

Potash, *Chromate of.*—It forms rhomboidal crystals without pyramids. Its colour is lemon yellow; its taste cold, bitter, and disagreeable; it is very soluble in water. It forms a double salt with sulphate of potash, and produces crystals, which sometimes contain only forty-four per cent. of chromate of potash. These crystals are sold for pure chromate of potash. —Dissolve the suspected chromate in water, add to the liquid a solution of nitrate of barytes as long as it produces a precipitate, pour off the supernatant solution, wash the precipitate with water, and afterwards pour nitric acid over it; this will dissolve the chromate of barytes, but leave the sulphate of barytes, if any is present, undissolved. The latter may then be still farther examined by the process described at p. 44.

Potash, *Nitrate of. Nitre. Saltpetre.*—

This salt is colourless when pure. It forms fluted prismatic crystals, often of very large volume. It contains no water of crystalisation, but is very soluble in water. At the freezing temperature one hundred parts of water dissolve thirteen parts of nitre; at the boiling temperature, one hundred parts of water dissolve two hundred and forty-six parts of nitre. The solution is colourless; its taste is piquant and cooling. At the temperature of 660 deg. it undergoes the igneous fusion, and gives a transparent, colourless liquid, which concretes on cooling into a white mass. Thrown upon burning coals, it fuses and deflagrates. Such are the characters of pure saltpetre.—The nitre which is found in commerce is never chemically pure. It always contains more or less of the following substances. Chloride of potassium, chloride of sodium, sulphate of potash, sulphate of soda, nitrate of soda, nitrate of potash, earthy matters, moisture, and a variety of substances which give it a brownish colour.

Detection of Chlorine.—1. Test the suspected nitre for chlorine by means of the blowpipe, according to the instructions given at p. 59.—2. Dissolve the nitre in water, filter the solution, and add to it a solution of sulphate of silver. If a precipitate is produced, chlorine is present. *Detection of Sodium.*—Test the suspected nitre for sodium before the blowpipe, in the manner described at p. 52. *Detection of Sulphates.*—Dissolve the nitre

in water, filter the solution, and add to it a solution of chloride of barium. The production of a white precipitate indicates the presence of sulphuric acid. *Detection of earthy Substances.*—They remain undissolved when the nitre is put into water. They can be separated by the filter, and dried and weighed if required. If nitre contains soluble earthy salts, its solution affords a precipitate with a solution of carbonate of potash. *Detection of Moisture.*—Weigh a little of the nitre in a small capsule; heat the capsule by placing it on hot sand or otherwise, and then again weigh it. If any loss of weight is observed, it arises from loss of water. *Detection of nitrate of Soda.*—As nitrate of soda burns very slowly, it is injurious to nitre which is intended to be employed in making gunpowder. Nitre which contains nitrate of soda is liable to become moist, because the latter salt is deliquescent. If the suspected nitre is found to contain sodium, but to be free from chlorine and sulphuric acid, the presence of nitrate of soda may be inferred. As nitrate of soda is very easily dissolved by water, it may be separated from nitre by washing the latter in a very small quantity of water. The solution should be evaporated to dryness, and tested for sodium, chlorine, and sulphuric acid.—When the nitre contains both chloride of sodium and nitrate of soda, the presence of the latter is difficult of determination. The deliquescence of the substance produced by washing the nitre is a sign which serves to indicate its presence. *Detec-*

tion of nitrite of Potash.—The presence of nitrite of potash in nitrate of potash, is liable to injure the quality of the gunpowder made therewith. The presence of nitrite of potash may be detected as follows:—Put a little of the suspected salt into a white glass tube closed at one end, and add to it a small quantity of sulphuric acid, slightly diluted with water. If the salt is a pure *nitrate,* white vapours of nitric acid will be disengaged. If it contain any *nitrite,* the white vapours of nitric acid will be mingled with yellowish-red vapours of nitrous acid.

The dark colour of nitre is often due to the presence of *organic substances,* but when it is owing to the presence of metallic oxides, the nature of the oxides may be determined by fusing the nitre with borax or microcosmic salt, before the blowpipe.

Detection of Copper.—Occasionally, saltpetre is found to contain copper. Its solution in this case gives, with liquid sulphuretted hydrogen, a brown precipitate, and with a solution of yellow prussiate of potash, a red precipitate.

As the weight of nitre is uselessly and often considerably increased by the foreign substances above-mentioned; it is of great importance to be enabled to determine the exact quantity of real nitre contained in any sample which may be presented for analysis.

1. The process most commonly followed in commerce is founded on the property possessed by a saturated solution of pure nitre, of being

able to dissolve the foreign salts which are contained in crude nitre.—You take a determinate weight of the nitre which is to be analysed, pulverise it coarsely, and place it in a capsule or mortar of glass. You then pour over it a saturated solution of pure nitre in water at the ordinary temperature, and you stir the mixture to facilitate the solution of the foreign salts. At the end of ten minutes you decant the solution, and repeat the operation with a fresh solution of nitre. You then spread the washed crystaline powder on a thick fold of bibulous paper to dry, and afterwards expose it in a warm place. When it is dry, you weigh it, after which you dissolve it in water, and separate the insoluble matters which it may contain, such as earth, sand, &c. You filter the solution, weigh the insoluble residue, and deduct its weight from the preceding. You have thus the weight of the pure nitre; but in the experiments made for commercial purposes, it is customary to neglect the determination of the weight of the insoluble substances, and to regard as pure nitre the substance left by the washing of the crude nitre with the saturated solution.

It is evident that this method of analysis, and the mode of executing it, present many chances of error. The first is, that the saturated solution of pure nitre becomes able to dissolve a new portion of nitre at the same temperature, after it has dissolved a certain quantity of chlorides. Other chances of error relate to the manner of executing the analysis.

But, such as it is, this process is sufficient for most commercial purposes, if the following points are attended to with suitable carefulness. The temperature of the solution ought never to vary during the washing, otherwise it may either dissolve nitre or deposit it. The salt must be reduced into fragments sufficiently fine to permit the washing to be effected completely. The crystals must be first well dried by gentle pressure between numerous folds of bibulous paper, and then submitted to the action of a moderate heat before being weighed.

2. Gay Lussac has pointed out a mode of analysis which affords better results, but which is longer and more difficult to perform. You mix, intimately, ten parts of the nitre for analysis with five parts of charcoal and forty parts of common salt. You ignite this mixture strongly in a crucible. The nitrate of potash is thus decomposed, and you obtain a mixture which contains all the chlorides which were in the nitre, the carbonate of potash resulting from the decomposition of the nitre, and an excess of charcoal. The mass is lixiviated, and a clear solution is obtained by filtration. You expel the carbonic acid by adding diluted sulphuric acid of a known strength. You ascertain the weight of pure sulphuric acid expended, and then calculate the quantity of carbonate of potash contained in the solution, and deduce thence the equivalent quantity of nitrate of potash. Every thirty-five parts of carbonate of potash is equivalent to fifty-one parts of nitrate of potash.

I have given but a superficial account of the processes necessary to be adopted in the analysis of nitre. It would take up too much space to describe all the minutiæ which are necessary to be attended to in the performance of this analysis; and the present work is intended to give instructions merely for qualitative and not for quantitative analysis.

Potash, *Superoxalate of.*—This salt forms opaque white crystals, which are permanent and not deliquescent in the air, have an acid taste, and redden moist litmus paper. It dissolves slowly in water, requiring ten parts of hot water for its complete solution.—The solution gives a precipitate with a solution of chloride of barium, but the precipitate must dissolve completely in nitric acid, otherwise it contains sulphuric acid. It must give no precipitate with sulphuretted hydrogen gas, otherwise it contains lead, copper, or some other metal. It gives a white precipitate with all solutions which contain lime.

Potash, *Sulphate of.*—Its solution should have no action on litmus or turmeric test paper. It should give no precipitate with a solution of sulphate of silver, otherwise it contains muriatic acid. It should give no white precipitate with hydrosulphuret of ammonia or solution of carbonate of ammonia, otherwise it contains zinc. A counter proof of the presence of zinc is, that the precipitate caused by carbonate of ammonia, re-dissolves in an excess of that re-agent. When heated in a glass tube, it should not give out an orange-

coloured gas, otherwise it contains nitrate of potash.

Bisulphate of Potash.—Is liable to contain sulphate of potash, known by its inferior degree of solubility in water. It also very often contains nitrate of potash, which may be detected by the process given above.

Potash, *Tartrate of. Soluble Tartar.*—This salt forms small white rhomboidal crystals. It should dissolve easily in water. The solution should have a gentle saline, and not an acid taste. It should give a precipitate when mixed with an acid, but only when not diluted with too much water. If it turns blue when mixed with ammonia, it contains copper. If it gives a blue precipitate when mixed with a solution of prussiate of potash, it contains iron. It often contains sulphate of soda or sulphate of potash, and chloride of potassium. The sulphates are detected by testing the solution with a solution of acetate of barytes. If the resulting precipitate is insoluble in nitric acid, the soluble tartar contains sulphates. The chloride is detected by testing the solution with a solution of nitrate of silver. If the resulting precipitate is insoluble in nitric acid, the soluble tartar contains chlorides. The soluble tartar of the apothecaries' shops often contains half its weight of cream of tartar. The soluble tartar should be dissolved in an equal weight of water: the cream of tartar then remains undissolved.

Potash, *Supertartrate of. Cream of Tartar.*—This is the product of the purifi-

cation of tartar. It forms grayish-white opaque and irregular crystals. Its taste is strongly acid. It dissolves in sixty parts of cold water and fifteen parts of boiling water. It is liable to contain the following impurities: tartrate of lime, pounded marble, pulverised siliceous pebbles, copper, and sulphate of potash.—To detect the *tartrate of lime*. Dissolve the cream of tartar in water, filter the solution and neutralise it with a solution of potash. The lime will then precipitate.—2. To detect the *marble*. Digest the cream of tartar in twenty parts of water, mixed with a little ammonia. The marble, as well as any sand or ground pebbles which may be present, will remain undissolved. Or, add a diluted acid to the suspected cream of tartar. If marble be present, an effervescence will be produced.—3. To detect the *copper*. Digest the cream of tartar with liquid ammonia. If copper is present, the liquid will become blue.—4. To detect the *sulphate of potash*. Mix a portion of the cream of tartar with three times its weight of distilled water. Agitate the mixture frequently for two hours, and then filter the solution. As the sulphate of potash is much more soluble than the supertartrate, the clear solution produced thus, will contain the sulphate of potash; the presence of this salt is known by the bitter taste of the solution and by its giving a white precipitate, insoluble in muriatic acid, upon being tested with a solution of chloride of barium (p. 53). Cream of tartar must be preserved in a dry state, and

never in solution. It is very easily susceptible of decomposition when in a moist state or in solution.

POTASH *and* SODA, *Tartrate of. Sal Seignette.*—Crystalises in large six-sided prisms, of which generally but one side is formed; has a shelly glassy fracture, and nearly resembles alum and borax. It easily dissolves in water. The solution gives precipitates with solutions of nitrate of lead and chloride of barium, but the precipitates must dissolve in nitric acid, otherwise the salt contains sulphuric acid. If nitrate of silver gives a precipitate which will not dissolve in nitric acid, it is due to the presence of muriatic acid. The solution ought to be neutral.

POTASSIUM, *Chloride of.*—It crystalises in cubes like common salt and is completely soluble in four parts of water. The solution should be perfectly neutral. It must give no precipitate when tested with a solution of chloride of barium, otherwise it contains sulphate of potash. It must not turn black when tested with liquid sulphuretted hydrogen, otherwise it contains lead, copper, or other metals.

POTASSIUM, *Iodide of. Hydriodate of Potash.*—It forms white opaque cubical crystals, similar to those of common salt. It is liable to contain chloride of potassium and chloride of sodium. I have known it to contain carbonate of potash.—The presence of carbonate of potash is detected by the effervescence produced by adding diluted acids to

a solution of the iodide.—The presence of sodium may be detected by heating the salt before the blowpipe (p. 52). The presence of chlorine may be detected by heating the salt on a copper wire as described at p. 59. It must be observed with reference to the process referred to, that whereas chlorides produce a fine *blue* flame under the given circumstances, iodides produce an equally splendid *green* flame and bromides a flame in which blue and green are intermingled.

Potassium, *Sulphuret of*.—When fresh prepared it forms a liver-brown mass, which has a shelly and somewhat greasy fracture. It is inodorous or smells of sulphurous acid. It becomes moist in the air, acquires a green colour, and then smells of sulphuretted hydrogen. It is entirely soluble in water. If it gives a black flocky residue, it contains silica or sulphuret of iron.

Prussian Blue.—Few substances occur in commerce of so variable a quality as the different samples of Prussian blue. One may generally procure fourteen or fifteen varieties, differing in the intensity and beauty of their colour. It is commonly adulterated with alumina, carbonate of lime, and sulphate of lime. But its commercial value depends less upon the weight of the foreign matter it contains, than upon the particular richness of its colour. Simple inspection of a sample is therefore sufficient to guide an experienced dealer in forming an estimate of its value. The only trial to which it is customary to

subject this drug is that of braying it with white lead in oil, and ascertaining the proportion of the blue which is required to raise a given quantity of the white lead to a determinate shade.

RHUBARB.—The varieties of rhubarb, known in commerce under the names of Russian, Turkey, and Indian, are all derived from one source; the finest and most perfect pieces being sold under the name of Russian and Turkey, rhubarb, and the inferior pieces as East Indian.—The best *Russian* or *Turkey* rhubarb is in roundish pieces, perforated with a large hole, of a yellow or reddish colour on the outside, somewhat soft and friable, and when broken, exhibiting many diverging streaks of a beautiful bright red colour. It has a peculiar aromatic odour and a bitter, slightly astringent, subacid taste; feels gritty between the teeth when chewed, and tinges the saliva of a bright yellow colour. It breaks with a rough hackly fracture, is easily pulverised, and affords a powder of a bright buff-yellow colour. It should not be porous, but rather compact and heavy. Alcohol extracts two and three-quarters from ten parts, and gives a tincture of a rich golden colour, which reddens tincture of litmus, is not altered in its transparency by the addition of water, and strikes a dark olive-blue with solution of sulphate of iron, without producing an immediate precipitate.

East Indian or *Chinese* rhubarb has a stronger odour, and is more nauseous to the

taste than the Turkey; it breaks with a smoother and more compact fracture, and affords a powder of a redder shade. Alcohol extracts four parts in ten; the tincture is of a much deeper colour and brownish; it gives a deeper red to litmus tincture, is rendered slightly turbid by the addition of water, and strikes a green not blackish olive, with sulphate of iron, which it also quickly and copiously precipitates.—It is a common practice to sort the rhubarb after its importation. The best pieces are picked out and cut into a proper form, and being thus freed from all worm-eaten or other depraved parts, are sold for Turkey rhubarb. The next best pieces are sold as Indian rhubarb, while the worm-eaten, or other unsightly parts, are used up in preparing tincture of rhubarb. A very considerable profit is made by this management. Rhubarb which has been kept some time is subject to be attacked by insects. It then becomes penetrated by a multitude of little holes, which druggists are in the habit of filling with a paste made of rhubarb powder and mucilage; after which they roll the mended pieces in the finest rhubarb powder to give them a good colour and an appearance of freshness.—It often happens that rhubarb which appears good at the exterior is black and moist inside. It is therefore necessary, in purchasing rhubarb, to take none without breaking and examining each lump.

Rheum Raponticum.—A considerable quantity of this rhubarb is annually delivered to

commerce. It bears an external resemblance to Turkey rhubarb, but differs from it considerably in medical properties. As druggists are accustomed to mingle it with Turkey rhubarb, it is necessary to learn how to distinguish the one from the other. The rheum raponticum is produced in irregular pieces three or four inches long, sometimes flattened, often rounded, from the size of the finger to that of the fist, of an open texture, and externally of a reddish colour; its fracture has a rayed appearance; its taste is mucilaginous and astringent. It is not gritty between the teeth; its odour is analogous to that of true rhubarb, but is less agreeable. Its powder is yellow, but of a dead and dull hue in comparison with the powder of Turkey rhubarb.

Rose Oil. *Otto of Roses.*—English oil is very inferior in odour to foreign oil and is apt to become rancid; the foreign oil is often adulterated with oil of sandal wood, and the crystaline appearance of the genuine otto is imitated by the addition of spermaceti.

Rose Water. Yellow sandal-wood water, rose root water, and aqua ledi palustris, are sold by apothecaries instead of rose water. Comparison of the taste and smell with genuine rose water is the method of discrimination.

Saffron.—The saffron which is grown in England is considered superior to any that is imported from other countries. The best saffron may be known by the breadth of the blades. It ought not to be of too deep a red

or orange colour, and should be fresh and tough, and possess a strong but pleasant aromatic odour. It ought not be kept more than twelve months. Foreign saffron is almost constantly sophisticated with oil; by which means the weight is much increased, while the flavour of it becomes frequently depraved. It is customary with druggists to subject foreign saffron to a preparation which consists in extracting the oil from it, and then pressing it into cakes similar in form to those of English saffron. It is thus passed off for English saffron, though in all respects greatly inferior to it. This substitution can be detected only by comparing the false saffron with the true; for which purpose a good specimen should always be kept on hand. The strong aromatic odour, the deep clear colour and the broad leaf of the English saffron are its most striking characteristics.

Saffron is adulterated, sometimes with flowers of carthamus or of marigold, sometimes with extraneous bodies intended to increase its weight, such as sand, lead, &c. The latter fraud is so gross as to be passed off with difficulty. As for the carthamus, it can be distinguished by its form. True saffron is the stigma of a plant, and appears in the form of long supple filaments. Carthamus is composed of a fine red-coloured tube, divided into five sections at its upper part, and still containing the organs of fructification. Its odour is far from being so agreeable or so powerful as that of saffron. A pinch of carthamus

thrown into water produces a brownish yellow solution, whereas true saffron immediately produces a beautiful golden yellow liquid. The saffron of commerce is sometimes found to have been either partially or entirely deprived of its colour by previous infusion. Such saffron has a pale red colour, and a dull and uniform appearance in the mass; its odour is fainter than that of good saffron, and it communicates to the saliva a very weak yellow colour. It is common with druggists, who wish to avoid the loss of weight attendant on the drying of saffron, to keep it in a moist place, such as a cellar. But this practice has sometimes the effect of giving rise to a slight fermentation, the consequence of which is the destruction of most of the good properties of the saffron.

SAGO.—It is in small hard grains, more or less round, and of a yellowish-white colour. When boiled with water, the grains do not mix with the liquid so as to form a paste, but swell up, become transparent, and form a mass of mucilaginous globules.

SALEP.—This substance comes from the East Indies. It should be in pieces having the form of almonds, or rather of long pebbles, with small cavities in various parts of their surface. It is never safe to buy it in powder, because in that state it is often mixed with factitious salep. The latter is prepared of potatoes, peeled, cut in slices, baked until brittle and then ground into powder.

SARSAPARILLA.—That which is preferred

is in long slender runners, proceeding from a common stem; it is bound up in bundles of various sizes, which very frequently contain extraneous substances in their interior, or faggots of rotten and decayed roots. Jamaica or red sarsaparilla is preferable to other varieties, in consequence of the large quantity of extractive matter which it affords. Hondura's sarsaparilla is not so good as the preceding; its bark is dirty brown or gray, and it is more fibrous and pithy. The sarsaparilla from Vera Cruz is of very bad quality.

Seeds.—The seeds which yield volatile oils by distillation, such as aniseed, are valuable in proportion to their weight. The heaviest seed yields the most oil. The way to examine them is to ascertain the weight of a given measure of the seed, and then to compare this weight with that of an equal measure of a sample of the same sort of seed of a determinate quality.

Senna.—The senna leaves are frequently mixed and adulterated with leaves of argol, bladder senna, box, and other plants. It is difficult to describe the characters which should guide you in the selection and purchase of senna; among them, I may enumerate a bright fresh colour, and an agreeable smell somewhat resembling that of green tea. It should not be too largely mixed with stalks, seed pods and other extraneous matter, nor very much broken, nor very dusty. It gives a brown solution with water, and a green solution with alcohol.

Silver.—Dissolve it in nitric acid. It must give no black insoluble deposit, otherwise it contains gold. It must not give a blue solution, otherwise it contains copper. The solution formed by dissolving *silver leaf* in nitric acid, must not become purple when mixed with a solution of chloride of gold, otherwise the silver leaf contains tin.

Silver, *Nitrate of. Lunar Caustic.*—(*a*) *Crystalised Nitrate of Silver* is perfectly white and of a tabular form. The crystals should remain dry in the air, and when in a dry state ought not to become in the slightest degree black on exposure to light. They must dissolve entirely in water and produce a colourless solution. The solution must give an abundant precipitate when tested with caustic ammonia; but the precipitate must entirely disappear when an excess of ammonia is added. The solution must then remain colourless: the slightest appearance of blue indicates the presence of copper. When the solution of nitrate of silver is precipitated by an excess of a solution of common salt, and the precipitate is separated by filtration, the solution must give no red precipitate with a solution of yellow prussiate of potash, otherwise it contains copper.

(*b*) *Fused Nitrate of Silver,* or Lunar Caustic.—When this salt is well prepared, the sticks are quite white. When contaminated with organic substances or formed by moulding in iron vessels, the colour is blackish. A very pale colour may be pardoned; it can be

due to the presence of reduced silver or a small quantity of copper. Strongly coloured preparations should be rejected. The operative chemist can avoid the reduction of a portion of silver in the preparation of lunar caustic, only by casting the fused mass in forms made of silver instead of iron. The fracture of lunar caustic must be crystaline and radiated; a conchoidal fracture signalises an impure preparation. It must be easily and entirely soluble in water, otherwise it is unfit for use. It will then be found to contain oxide of copper, reduced silver, or chloride of silver; most generally the latter. The solution must be perfectly colourless and transparent, and must behave towards liquid ammonia, precisely like the solution of the crystalised nitrate of silver. But if, on a careful addition of the ammonia, a *slight*, instead of an *abundant* precipitate is produced, it is strong evidence that the preparation contains saltpetre. To put this to the proof, the solution must be precipitated with an excess of muriatic acid, and when no more chloride of silver falls down on the addition of fresh portions of this re-agent, the solution must be filtered from the precipitate and evaporated to dryness. If a residue is afforded which deflagrates when thrown upon burning coals, the presence of saltpetre in the lunar caustic is demonstrated.

The substance deposited by impure lunar caustic during its solution in water may be oxide of copper, reduced silver, or chloride of

silver.—1. If it dissolves easily in nitric acid, without producing red fumes, and gives a solution which becomes blue when tested with ammonia, it is oxide of copper.—2. If it dissolves slowly in nitric acid under production of red fumes, and forms a solution which does not become blue with ammonia, it contains reduced silver. In this case, the sticks of lunar caustic possess a corroded appearance, and seem to contain air bubbles.—3. If it is insoluble in nitric acid, but easily soluble in ammonia, or if it readily becomes black in the light, it is chloride of silver.

Snuff.—Snuff is adulterated with inferior sorts of powdered tobacco, and frequently with vegetable powders entirely free from odour, such as the sweepings of snuff-shops, pulverised nut shells, and the powder of old rotten wood, called *powder post*. The colour is improved by ochre or amber, and the appearance and feel is modified by an addition of treacle or urine. Common salt is added to increase the weight of the snuff, and muriate of ammonia to increase its pungency. Sugar-candy and powdered glass, are also cited as adulterants of snuff. When a little adulterated snuff is gently placed on the surface of a glass of water, the solid substances it may contain (such as glass), fall immediately to the bottom, the pure snuff will sink more slowly, the common salt and muriate of ammonia will dissolve in the water, and may be detected by adding the tests for chlorine (p. 58). The flavour of snuffs may be tested

by smoking them in a tobacco-pipe. When mixed with ammoniacal salts, the fraud may be detected by moistening the snuff with a solution of caustic potash, which will cause it to smell strongly of ammonia.

Soap.—The substance most generally employed to adulterate soap is white clay, the presence of which is easy of detection.—1. Scrape an ounce of the suspected soap into thin shreds, pour boiling water over it in a basin, mix the whole till it forms a uniform paste, and then allow it to settle for the space of twelve hours near the fire. At the expiration of that time turn out the cake of soap, and examine the under side, to see whether any clay has settled there.—2. Dissolve one part of scraped soap in six parts of alcohol, by means of a gentle heat, performing the operation in a bottle or small flask. If any clay be present, it will remain undissolved.—The dull red colour of certain fancy soaps is communicated by red ochre. If such soaps are dissolved in water or alcohol, the red ochre sinks to the bottom of the solution.

Medical Soap.—This is prepared from caustic soda and olive oil. No other kind of soap ought to be employed in medicine. When properly prepared, it is tough, has a greasy feel, and is free from alcalinity. It must dissolve in water, and give neither drops of oil, nor insoluble residue. If it contains lime, gypsum, or pipe-clay, these substances will remain undissolved.

Soda, *Subborate of. Borax.*—This salt

crystalises in white four or eight-sided pillars with blunt edges. It fuses when exposed to heat, and produces a clear and colourless glass. It must not decrepitate when heated, otherwise it contains common salt. A small piece may be tried on charcoal before the blowpipe. This experiment serves to distinguish borax from alum and sal seignette, both of which externally resemble borax, but do not fuse like it into a colourless glass. It dissolves in twelve parts of water. The solution must not be precipitated by solutions of the alcalies, otherwise it contains alum. It must, when diluted, give no precipitate with a solution of chloride of barium, otherwise it contains sulphuric acid, nor with a solution of sulphate of silver, otherwise it contains muriatic acid.

A variety of borax is prepared in France and probably also in England, which is much better adapted to the use of jewellers, than the common borax. It crystalises in octahedrons which combine into irregular masses. It is very hard, and grinds into powder much easier than common borax; it is very sonorous and does not effloresce in dry air. One hundred parts contain only thirty parts of water of crystalisation, whereas one hundred parts of common borax contain forty-seven parts of water.

Soda, *Crude Carbonate of.*—The soda of commerce is a mixture of carbonate of soda with a great variety of other salts and insoluble substances. The substance termed *Barilla*

is an extremely impure carbonate of soda. The analysis of soda is performed in the same way as the analysis of potash (see page 211), the object being generally to ascertain how much carbonate of soda is contained in a given weight of the impure soda. The operation is one of great importance to persons engaged in various arts, but I am obliged to pass it over, on account of the great details it would require.

Artificial Soda.—This is an impure carbonate of soda in crystals, prepared by decomposing common salt by sulphuric acid, and then decomposing the resulting sulphate of soda by ignition with charcoal. It often contains chloride of sodium and sulphate of soda in considerable proportion, and is therefore unfit for chemical use without previous purification. The presence of the foreign salts is discovered by dissolving the carbonate of soda in diluted nitric acid, and adding a solution of sulphate of silver to throw down the chlorine in the form of a white precipitate, and a solution of chloride of barium to detect the sulphuric acid in the same manner.

Soda, *Carbonate of. Purified Carbonate of Soda.*—This salt crystalises in white rhomboidal octahedrons, which effloresce in the air, and are easily soluble in water. It is apt to contain sulphate of soda and chloride of sodium, indeed it is seldom free from those two salts, because the manufacturers sometimes keep them designedly in the solutions of soda to make the carbonate crystalise with greater

readiness. *Analysis:*—Dissolve the carbonate of soda in nitric acid, and add to separate portions of the solution, a solution of chloride of barium and a solution of sulphate of silver. The barytic salt gives a white precipitate with sulphates, and the silver salt gives the same with chlorides. When the solution of carbonate of soda is neutralised with muriatic acid, it must not give out the smell of sulphuretted hydrogen; and when the solution is tested with a solution of nitrate of lead, it must give a white and not blackish precipitate, otherwise the salt contains sulphuret of sodium.

Soda, *Bicarbonate of.*—It crystalises in four-sided tables, which do not effloresce in the air. It is soluble in eight parts of water, and forms a neutral solution. This must give no precipitate with a solution of chloride of calcium, otherwise it contains the common carbonate of soda.

Soda, *Phosphate of.*—It crystalises in large colourless rhomboids, which effloresce in the air, and commonly appear white at the surface. It dissolves completely in four parts of water. The solution must be neutral in its action on turmeric paper, and not effervesce with acids, otherwise it contains carbonate of soda. It produces a precipitate with a solution of nitrate of silver, which must dissolve in nitric acid, otherwise it contains chloride of sodium. It produces a precipitate with a solution of chloride of barium, which must dissolve in muriatic acid, otherwise it contains sulphuric acid. It must give no precipitates with a solution of

prussiate of potash, with liquid sulphuretted hydrogen, or hydrosulphuret of ammonia, otherwise it contains lead, copper, or some other metal.

SODA, *Sulphate of. Glauber's Salt.*—If this salt contains acid in excess, its solution reddens litmus paper; if it contains alcali in excess, its solution turns turmeric paper brown. If it contains chloride of sodium, its solution gives a white precipitate with a solution of sulphate of silver. If it contains iron, it gives a blue precipitate with a solution of the yellow or red prussiate of potash. If it contains copper, it gives a brown precipitate with liquid sulphuretted hydrogen.

The resemblance of crystalised nitre to Glauber's salt has sometimes led to the accidental substitution of the former for the latter; and in doses of half an ounce to an ounce (the usual dose of sulphate of soda) nitre proves virulently poisonous, exciting violent spasms, vomiting, bloody stools, convulsions, and often proving fatal. The two salts are easily distinguished by chemical experiments. A solution of the sulphate of soda gives a white precipitate with a solution of chloride of barium; but a solution of nitrate of potash gives no precipitate. The nitre deflagrates when thrown on burning coals; the sulphate of soda does not. The nitre produces a violet flame before the blowpipe, the sulphate of soda a fine yellow flame.

SODIUM, *Chloride of. Common Salt.*—This substance exists ready-formed in great abund-

ance in nature. It is found in some situations in the solid state, but most commonly in solution in sea-water and salt-springs. It is obtained from the latter sources by evaporation. —The liquids which afford chloride of sodium generally contain a variety of other salts in solution, and in particular the chlorides of calcium and magnesium. When such liquids are evaporated, the crystals of salt which separate retain a portion of these extraneous substances in their interstices. This is the reason that common salt sometimes possesses a bitter taste, and is found to become moist in the air. But as the proportion of the foreign chlorides is generally very small, and without any injurious effect upon the human frame, the chloride of sodium is frequently delivered to commerce without undergoing purification: in this state it has generally a gray colour.

It is customary with some traders to add six or eight *per cent.* of sulphate of lime to their impure common salt. This adulteration has the triple advantage of making the salt heavier, and whiter, and less liable to appear moist: but this substance is injurious when taken into the stomach in considerable quantities. There is another substance which occasionally makes its appearance in common salt, and which, though it be not added fraudulently, is nevertheless liable to produce serious accidents if taken regularly for a long period; this substance is iodine. It has been found in large quantity in the common salt which is an accessary product in the preparation of iodine

from the sodas of Vareck: this common salt is collected and sold by the persons who manufacture iodine. The state in which iodine exists in common salt, is that of iodide of sodium.

To detect the chlorides of Calcium and Magnesium.—Dissolve the suspected salt in water and add a solution of subcarbonate of soda; this will throw down a white precipitate if either of these earthy compounds is present. Allow the precipitate to subside, filter the solution, and dissolve the precipitate in muriatic acid. Treat the resulting solution with muriate of ammonia and oxalic acid, in the manner described at page 173. If a white precipitate of oxalate of lime is produced, filter the solution, pour it into a little glass bulb and boil it with an excess of a solution of carbonate of potash. If this produces a white precipitate, it will consist of magnesia: of course you take care to add a sufficient quantity of oxalic acid to precipitate the whole of the lime before you attempt to detect the presence of the magnesia.

To detect Sulphate of Lime in common Salt.—Wash the suspected salt with three or four small portions of cold water. This will dissolve the chloride of sodium and leave the sulphate of lime undissolved. Afterwards dissolve the sulphate of lime in a large quantity of water, and test the solution for lime by means of superoxalate of potash (p. 45), and for sulphuric acid by means of chloride of barium (p. 53).

To detect Iodine in Common Salt.—Treat the suspected salt with alcohol. This dissolves the iodide of sodium and a small portion of the chloride of sodium. Filter the solution, evaporate it to dryness, and dissolve the residue in water. Mix the resulting solution with the solution produced by boiling starch in water. Add to this mixture a little nitric acid or a few drops of liquid chlorine. If iodine is present, the mixture will then assume a beautiful blue colour, the hue of which will be deep in proportion to the quantity of iodine which is set free by the nitric acid or chlorine. An excess of the last-named re-agent destroys the blue colour.

SODIUM, *Iodide of.*—The crystals must dissolve in water, and form a colourless solution. A solution of nitrate of lead must give a fine yellow precipitate, and a solution of nitrate of mercury a red precipitate. If the precipitates appear brown or blackish, the iodide of sodium contains sulphur.

SPANISH LIQUORICE. *Black Sugar.*—This substance is obtained by evaporating to dryness a decoction of the liquorice root. It is imported from Spain and Sicily in round sticks of five or six inches in length, and one inch in thickness. Its fracture is smooth and brilliant, its internal colour deep black, its taste sweet and agreeable. When the sticks are packed up in boxes, previous to exportation, they are stratified with dry bay leaves, to hinder their adhesion to each other. In spite of this precaution, however, they generally lose their

original cylindrical form, and conglomerate into masses.—It is usual to meet in commerce with Spanish liquorice of an inferior quality, manufactured by mixing a solution of genuine Spanish liquorice or of stick liquorice, with a solution of some cheap kind of gum, and then evaporating the solution till it produces a mass of sufficient consistence to bear rolling into cylinders sembling those of the true liquorice. This factitious article is packed up in boxes with strata of bay leaves, like the genuine liquorice imported from Spain.—When liquorice is broken, it must be black, smooth, and shining; the taste sweet and not empyreumatic; it must not become moist when exposed to the air in a dry place; it should dissolve in water without leaving any residue.

Refined Liquorice.—Instructions for preparing it:—Take one pound of Spanish liquorice, half a pound of gum Arabic, and enough water to dissolve the mixture; strain the solution through muslin; evaporate it gently till it forms a soft extract; roll it into cylinders the size of a quill; cut these into lengths, and polish by rubbing them together in a box.—An inferior kind is prepared by dissolving Spanish liquorice with an equal weight of *carpenter's glue.* If this kind is heated in a glass tube, or before the blowpipe, it gives out the odour of ammonia or hartshorn.—Another variety of refined liquorice is made by mixing a solution of Spanish liquorice with *starch.* If is found in commerce in little sticks, which are perfectly cylindrical, and very flexible; its

fracture is dull and granular, and sometimes exhibits minute white points, which no doubt result from an imperfect mixture of the component parts of the compound. It divides between the teeth into small lumps, and does not possess the tenacity of the pure liquorice. Treated with cold water, it dissolves but partially, and immediately deposits a dirty white powder, possessing the well-known properties of starch.

Starch.—It should be in prismatic hexagonal columns, more or less regular, and the powder of which, though soft to the touch, should make a peculiar sound when compressed between the fingers. It ought to be perfectly white. It should not form gray-coloured heavy irregular lumps. If it instantly deposits a heavy powder when stirred in water, it contains earthy matters. If a dirty scum floats on the top of the water, it contains other impurities.—Potatoe-starch is distinguished from wheat-starch by a very sensible crystaline appearance.—Starch which has been tinged blue by smalt or indigo should never be employed for food or medicine.

Steel.—Place a drop of diluted nitric acid on the metal which is to be examined; let it remain a few minutes, and then wash it away. If it leaves a black stain, the metal is steel; if it leaves a greenish-white stain, the metal is iron.

Strychnine.—It is liable to contain brucine. Moisten the suspected strychnine with nitric acid: if it assumes a blood-red colour, it contains brucine; if not, it is pure. Mix a

solution of the strychnine with a solution of chloride of tin: if it produces a brown precipitate, it contains brucine; if not, it is pure.

SUGAR. *Loaf Sugar.*—Choose that which is hard, close in texture, white in colour, and brilliant from the interspersion of shining facets of crystals. The sugar which is soft and breaks easily, which is dirty in colour, loose or spongy in texture, and free from crystaline splendour, is inferior in sweetening power, and often intermixed with impurities. The sugar which is manufactured in France from *beet-roots,* possesses the latter qualities in an eminent degree. The *cane* sugar is that which of all varieties of sugar most easily assumes a hard crystaline form, a close texture, and a white colour. It has been asserted that white marble is sometimes put into loaf sugar to improve its appearance. If this be true, the adulteration is a clumsy one; for if the sugar is dissolved in water, the marble remains behind in a solid and insoluble state, and is thus easily detected. Lime, chalk, gypsum, and plaster of Paris, are all liable to the same mode of detection. I believe that "Death in the Pot" is wrong in stating the employment of these substances by the sugar-baker.

Moist Sugar.—Choose that of which the grains are sharp, bright, hard, and loose, and which possesses a clear brownish colour. The sugar which is very soft and close grained, is inferior to that which has a crystaline appearance. The East India sugars, though whiter

than those which come from the West Indies, are inferior in sweetening power.

There is a kind of moist sugar manufactured in this country from treacle. It is very white in colour, and characterised by extreme fineness and softness; it bears the name of *crush-lump*. This variety of sugar is made in large quantities at Glasgow, and has come much into use in consequence of its fine appearance. However, in sweetening power, crush-lump stands far below the brown sugar of the West Indies.

The grocers are in the constant habit of preparing moist sugars for sale by mixing the common sorts of brown sugar with certain proportions of crush-lump. A mixture of this kind may be recognised by the uniformity of its appearance. Having been well-pounded, mixed, and sifted, it is free from the hard brown lumps, which ever occur in genuine moist sugar.

The substances most commonly considered to be employed in the adulteration of moist sugar, are sand and salt. The first of these is certainly not much in use, and I question whether the last is to be met with very frequently. If sugar contains sand it must deposit it when dissolved in water, and if it contains salt, the liquor must taste of the salt. But the presence of the most minute proportion of salt may be detected with ease by exposing the aqueous solution of the suspected sugar to the tests for soda and muriatic acid, which I have described at pp. 51 and 58.

An opinion pervades the vulgar mind, that loaf sugar retains the blood which is employed in the operation of refining it. The ground of this opinion is, that loaf sugar becomes red when exposed to the flame of a candle. It ought to be generally known that blood is employed in the clarification of solutions of sugar, solely in consequence of its containing albumen, or white of eggs, as a principal constituent; that the albumen precipitates in a solid state in combination with the impurities of the sugar during the operation; and that, consequently, neither albumen nor blood remain in the clear solution which is afterwards submitted to crystalisation. Moreover, sugar is frequently clarified by other means than the employment of blood.—As for the red colour produced when sugar is heated in the flame of a candle, it is merely the characteristic of *a substance produced* by the exposition of sugar to an elevated temperature.

Sulphur.—Sulphur or brimstone, is found in commerce in three different states, namely, as rough sulphur, roll sulphur, and flowers of sulphur. It is subject to various contaminations, and roll sulphur especially is said to contain sulphuret of arsenic. Its purity may be determined by boiling one hundred grains in four ounces of oil of turpentine: the solution is poured off while hot, and it deposits the sulphur it had dissolved, as it cools: the cold oil may then again be boiled on the residue, and again cooled, and this operation repeated as long as it dissolves anything: the

weight of the insoluble residue indicates the amount of impurity.

The presence of arsenic may also be detected as follows:—Boil the sulphur in nitric acid, filter the solution, neutralise it with lime and again filter it. If a solution of nitrate of silver produces a precipitate when added to the clear solution, it indicates the presence of arsenic. Boil the sulphur in nitro-muriatic acid, evaporate the mixture to dryness, to expel the excess of acid; dissolve the residue in water, filter it and pass a current of sulphuretted hydrogen gas into the clear solution. If arsenic is present, a yellow precipitate will be produced.

In most cases, the impurities which occur in sulphur, consist of earthy substances, particularly silica, carbonate of lime, iron, alumina, and magnesia, but it also often contains a peculiar bituminous matter. The proportion of earthy substances which exist in rough sulphur is from five to seven *per cent.* but it is sometimes greater. The process employed to determine the presence of foreign substances, consists in burning away the sulphur, so as to leave the impurities in a state of freedom. The presence of bitumen is recognised by the fetid odour which the suspected sulphur exhales on being inflamed, or even on being strongly rubbed. The residue of the dry distillation of bituminous sulphur contains a quantity of charcoal resulting from the decomposition of the bitumen, and the distilled sulphur has often a reddish appearance in con-

sequence of the presence of a proportion of bitumen.

The *Flowers of Sulphur* obtained by distilling rough, or roll sulphur, always contain a little sulphuric acid. It is freed from this by washing with water, an operation which ought never to be neglected when the sulphur is to be employed medicinally. If it is required to know whether flowers of sulphur have been washed, they should be agitated with water, and the clear solution tested with litmus paper and a solution of chloride of barium. The change of the blue litmus to red, and the production of a precipitate with chloride of barium, demonstrate the presence of sulphuric acid.

Sulphuric Acid.—When sulphuric acid, or oil of vitriol, is in a state of purity, it forms a perfectly colourless liquid, of the specific gravity of 1·850, being nearly twice as heavy as water.

If the acid is coloured, it indicates the presence of organic matter. It ought to volatilise without the smallest residue, when heated in a platinum spoon. If it contains iron, lead, alum, sulphate of potash, or other salts, they will remain in the spoon.—It ought not to attack mercury when cold, otherwise it contains nitric acid.—When diluted with water, it ought not to become troubled, otherwise it contains sulphate of lime, sulphate of lead, or some such salt. Neither ought the diluted acid to give any precipitate with a solution of sulphate of silver, otherwise it contains mu-

riatic acid.—When neutralised with ammonia it ought not to become troubled, nor should the neutralised liquid give the least indication of a metallic precipitate when tested with hydrosulphuret of ammonia, or liquid sulphuretted hydrogen. If it becomes brown or black, the presence of lead may be suspected.

Sulphuric Ether.—It forms a perfectly colourless and transparent liquid. It must evaporate without leaving the least residue. It must burn with a brighter flame than alcohol, give but little smoke and leave no residue. It must not redden litmus paper. When shaken with an equal volume of water, its own volume must not be much diminished, otherwise it contains alcohol or water. When mixed with water and a solution of chloride of barium or acetate of barytes, it must not become troubled, otherwise it contains sulphuric or sulphurous acid. The specific gravity of anhydrous ether is 0·706. It is unfit for medical use when it is above 0·732.

Tamarinds.—We find two sorts of tamarinds in commerce, the one black, the other red; the first is that which is most esteemed. Tamarinds frequently contain copper, which is derived from the vessels in which the pulp has been made to undergo an evaporation. The method commonly employed to recognise the presence of copper in tamarinds, is that of plunging a bright plate of iron into the mass and permitting it to remain there some time. If the tamarinds contain copper, this metal is

deposited on the plate of iron, to which it gives a reddish colour (p. 4). The operator may also calcine a portion of the tamarinds and seek for the presence of copper in the carbonaceous residue afforded by the calcination. (See p. 5.) Tamarinds are sometimes imitated by a mixture of small black prunes with tartaric acid or supertartrate of potash; but this sophistication is easy to be detected in consequence of the absence of the smooth hard quadrangular seeds which form part of the genuine tamarinds. When, however, the false tamarinds are mixed with the true tamarinds in nearly equal proportions, the cheat is difficult of detection. But there is no reason to suppose that this sophistication is much practised when tamarinds are cheap.

Tapioca.—This substance has recently been imitated by the manufacturers of vermicelli. *True tapioca* is in lumps of various sizes, rough to the feel, opaque, very hard, somewhat elastic, of a white tending to rust colour, and having a taste slightly analogous to that of beans. Treated by boiling water, it produces a viscous jelly, which is semi-transparent, inodorous, and insipid.—*Artificial tapioca* is in round and nearly regular grains, which are whiter, less opaque and more easily broken by the teeth than the grains of true tapioca. The starch which it produces with boiling water is opaque, its taste insipid, and its odour analogous to that of the paste prepared from wheat-starch or potatoe-starch.

Tartaric Acid.—This acid is found in

commerce in transparent colourless crystals. Tartaric acid should dissolve completely in twice its weight of water. If the resulting solution affords a precipitate when tested with a solution of chloride of barium, and the precipitate will not dissolve in muriatic acid, it shows that the tartaric acid contains sulphuric acid. If the solution of tartaric acid after being neutralised by ammonia, gives a precipitate when tested with a solution of superoxalate of potash, it shows that the tartaric acid contains lime. If the solution becomes blue when mixed with ammonia, it denotes the presence of copper. If the solution becomes black when tested with liquid sulphuretted hydrogen, it proves that lead is present.—When the crystals of tartaric acid become moist on being exposed to atmospheric air, the presence of a portion of malic acid is to be inferred. This can be separated by dissolving the tartaric in water, and re-crystalising it.—When tartaric acid will not wholly dissolve in twice its weight of water, the residue may contain potash, the presence of which can be demonstrated by the methods described (p. 50). Tartaric acid can only be preserved in the solid state. Its solution rapidly decomposes; in summer time, even in twenty-four hours.

Tea.—According to various authors who have written on the subject, the adulterations of tea are as follows:—Old tea-leaves are bought up at coffee-houses, and after being dried, dyed, and curled up, are sold again as

pure tea.—The leaves of the white thorn are boiled, dyed, dried, curled up and sold for green tea.—The leaves of the sloe tree are manufactured by a similar process into black tea.—The substance employed to colour false tea black is logwood; that which is employed to colour tea green is carbonate of copper.—Taking it for granted that the above statement is true, although this has been vehemently denied, I shall proceed to show in what manner the different cheats may be detected.

Form of the leaf.—The leaves of tea may be discriminated from the leaves of other plants by the following characters. The tea-leaf is slender and narrow, acutely pointed at the end and deeply jagged at the edges; the texture of the leaf is delicate, its colour a lively pale green, and its surface smooth and glassy. To put the leaves in a good state to be examined, it is proper to macerate them some hours in water and then to spread them out on a table to their full extent. The leaf of the sloe is much broader in proportion to its length than the leaf of tea; it has a rounder form; its point is obtuse, and not acute like that of tea, and the jags on the edge are far smaller. The surface of the leaf is more uneven; the texture less delicate; and the colour a dark olive green.

Detection of Logwood.—1. Moisten the suspected black tea and rub it on white paper. If it produces a bluish-black stain, it has been dyed with logwood.—2. Macerate the tea in

cold water. If it produces a blackish tincture which turns red on the addition of a few drops of sulphuric acid, it has been dyed with logwood. If the tincture produced by macerating the tea in water is of an amber colour, and does not become red when tested with sulphuric acid, the tea is pure. Solutions of logwood have the property of being reddened by acids.

Detection of Carbonate of Copper. Agitate a small quantity of the suspected green tea with a little diluted liquid ammonia in a small phial or glass tube. If copper is present, the liquid will become of a beautiful blue colour. Or you may submit the tea to any of the processes for the detection of copper, which I have described between pp. 1 and 8.

It is useless to make a long story about the adulterations of tea. I do not believe in the common employment of salts of copper as colouring matters, in my opinion, the grocers' knavery is most frequently manifested in selling the poorer sorts of tea at the price of the better sorts.

TIN.—This metal is most frequently adulterated with lead, which may be detected as follows:—Boil the tin in pure nitric acid, until it is entirely converted into white oxide of tin. Wash this powder with water, filter the solution and test it with sulphuric acid. If lead is present, a white precipitate is produced. Another metal which frequently accompanies tin is copper. The solution

filtered from the precipitated sulphate of lead, is mixed with ammonia; it is afterwards supersaturated with nitric acid and tested with a solution of prussiate of potash. If the ammonia renders it blue and the prussiate of potash produces a red precipitate, the presence of copper is demonstrated. Most samples of tin contain arsenic. To detect this metal, the tin is dissolved in concentrated muriatic acid, and the hydrogen gas which it disengages is led into a solution of corrosive sublimate. If it produces a white precipitate, it indicates the presence of arsenic; but if the solution of corrosive sublimate remains untroubled, the tin is free from arsenic. The arseniuretted hydrogen gas, disengaged during the solution of arsenical tin in muriatic acid, is recognised by its extremely fetid odour. The operator should take care not to respire an atmosphere contaminated by this gas; for it is so extremely poisonous, that GEHLEN, the German chemist, was killed by smelling it.

TOBACCO.—Soak it in water, filter the liquor through paper, evaporate it to a small bulk, and test it for nitric acid (p. 56), and potash (p. 50). These compounds are the ingredients of saltpetre, which is added to make bad tobacco burn readily. Boil the tobacco in diluted nitric acid, and test the filtered solution for lead (p. 8), copper (p. 2), and antimony (p. 14). Let the solution in water be also tested for the sulphuric acid (p. 53), and alumina (p. 48), which indicate the presence of alum; and for the chlorine (p. 58), and

mercury (p. 29), which indicate the presence of corrosive sublimate.—Sugar, black hellebore, and dried dock leaves are less easy of detection. When tobacco has a fetid odour, it has been badly prepared; when it is too pungent, or too aromatic, it contains cascarilla or other drugs. The smoke of adulterated tobacco is very injurious to the lungs.

Ultramarine.—The high price of this colouring matter is a strong inducement to adulteration. Put a small portion of a suspected specimen into concentrated nitric acid: if genuine, it speedily loses its colour and becomes white. If washed from the acid and ignited, it regains its blue colour. When rubbed in the palm of the hand, and viewed obliquely it ought to exhibit no brilliant points, otherwise it is not sufficiently pulverised.

Volatile Oils.—Volatile oils form part of all odorous plants. The continual evaporation of these oils is the cause of the agreeable perfume diffused by such plants in the atmosphere. Volatile oils are generally obtained by submitting the plants which contain them to distillation with water. They constitute but a very small proportion of the vegetables from which they are obtained, and bearing consequently a very high price, there is a considerable temptation to adulterate them. The most common adulterations are as follow:

(*a*) *Fixed Oils, Resins, and Balsam of Copaiva, dissolved in the Volatile Oils.*—To detect these compounds, let a little of the

oil be dropped upon paper, and evaporated by a very gentle heat. Pure volatile oil flies off without leaving any residue, but the adulterated oil leaves a semi-transparent stain upon the paper.—When the adulterated volatile oil contains fixed oil, the latter is detected by shaking the volatile oil with three times its bulk of alcohol, of the specific gravity of 0·84, in which the volatile oil dissolves, but the fixed oil remains undissolved. A portion of the balsam of copaiva, if any is present, remains also undissolved. To separate the resin, the volatile oil must be distilled with water.

(*b*) The volatile oils are sometimes adulterated with *Spirits of Wine*. This is detected by shaking the oil with water in a graduated glass tube. The liquid becomes milky, and after it has settled, and the oil and water have separated, the oil is found to have diminished in bulk and the water to have increased. The loss of bulk of the oil indicates the extent of the adulteration.

(*c*) *Expensive Oils are adulterated by mixture with cheap Oils.*—It is difficult to detect adulterations of this sort otherwise than by the smell and taste. Drop some of the oil upon a cloth, shake the cloth in the air, and then smell it. When mixed oils are treated thus, you can often detect the odour of one at the beginning, and of the other at the end of the evaporation. The odour of oil of turpentine can be very distinctly detected in this manner. Oil of turpentine can also be de-

tected by shaking the mixed oil with three or four times its bulk of alcohol of the specific gravity of 0·84. This re-agent leaves the greater part of the oil of turpentine undissolved. When a volatile oil which is heavier than water is adulterated with another which is lighter than water, they can be separated by a long agitation with water. After the mixture has settled, the light oil swims above and the heavy oil sinks below the water. Nevertheless, it sometimes happens, that a pure oil on being shaken with water, gives out a small quantity of an oil either lighter or heavier than itself. Hence the indications afforded by this method of examining oils require to be interpreted by some one who possesses a certain degree of knowledge of the habitudes of various oils.

A vast quantity of the sweet-smelling oils which are sold in sixpenny bottles, decorated with French labels, by the inferior perfumers of the metropolis, consist entirely of olive oil, or oil of turpentine, scented with a few drops of the volatile oil whose name appears on the French label. This is the case with the common rose oil, oil of rosemary, oil of lavender, and many other species. You will not be long in finding this to be the fact, if you put the foregoing instructions for the examination of such oils into practice.

Water.—It is of the utmost importance in common life to be provided with plenty of pure water. When a man is about to build a house or to establish a manufactory, one of

the first things to which he should direct his attention, is the means of bringing to the spot an abundant supply of this very necessary article. No person can live in a comfortable manner where water is scarce; and no manufactory in which water is employed, can be carried on with advantage unless the water is obtained in a state of purity, with regularity, and in great abundance.

Water collected from springs, rivers, lakes, and other sources, has been found to contain the following substances, combined in various methods and in very different proportions. *Bases:* potash, soda, lithia, ammonia, strontian, lime, magnesia, alumina; and the oxides of manganese, iron, zinc, and copper. *Acids:* sulphuric acid, sulphurous acid, nitric acid, carbonic acid, boracic acid, phosphoric acid, and silicic acid. Also, chlorine, fluorine, bromine, iodine, and sulphur, combined with a metal of one of the above-named bases. The reader who wishes to have full instructions for the detection of these numerous substances, may consult a paper by Rose, of Berlin, a translation of which, by Griffin, appeared in the fifteenth number of the "*Glasgow Medical Journal.*" In the present work, I shall confine myself to giving instructions for the detection of such compounds as occur in waters most frequently. These are, lime, potash, soda, alumina, magnesia, iron, lead, silica, organic remains, muriatic acid, sulphuric acid, carbonic acid, and sulphuretted hydrogen. Let it be supposed that you have

a water to examine, and wish to learn which of the above substances are contained therein. The method of proceeding is as follows:

Detection of Iron. Pour a portion of the water into a bottle, neutralise it with ammonia, and add a little hydrosulphuret of ammonia. If no precipitate is produced, the water contains no iron, neither does it contain lead, manganese, zinc, or copper, which sometimes occur in waters. If a black precipitate appears, separate it from the solution by filtration; put the precipitate without previous edulcoration into muriatic acid, add a small quantity of nitric acid, boil the mixture, and then filter it. Divide the solution into two portions, and test it with liquid ammonia and solution of yellow prussiate of potash. If iron is present, the former produces a brown, and the latter a blue precipitate. The addition of tincture of galls to fresh-drawn spring water which contains carbonate of iron, communicates a violet colour to the water. A solution of red prussiate of potash produces a blue precipitate in the same circumstances.

Detection of Lead. Add to the water a little diluted sulphuric acid, which produces a white precipitate in solutions which contain lead. If lime is present, it precipitates with the sulphate of lead, yet only when the quantity of lime is considerable. The method of distinguishing sulphate of lead from sulphate of lime has been described at page 8.

Detection of Alumina. Mix a portion of

the water with a slight excess of ammonia, making use of a flask which can be closed, to prevent the re-action of atmospheric air. Before the water is put into the flask it should be evaporated to the fifth of its original bulk, and then be filtered and acidulated with muriatic acid. If the addition of ammonia to the clear, concentrated and acidulated mineral water produces a white precipitate, it indicates the presence of alumina. If the precipitate is brown, the alumina is accompanied by iron.

Detection of Lime. The mineral water, either fresh-drawn or concentrated by evaporation, is first supersaturated by ammonia, as described in the preceding paragraph, and, after being filtered, is mixed with a solution of oxalate of potash. If the water contains lime, a white precipitate is produced.

Detection of Magnesia. To the solution filtered from the oxalate of lime add a solution of phosphate of soda. If magnesia is present a white precipitate will appear, either immediately, or after some delay. When a mineral water is suspected to contain a considerable quantity of magnesia, it is advisable to acidulate it with muriatic acid previous to the addition of the ammonia, otherwise the magnesia is liable to be precipitated with the alumina.

In performing the above experiments, you are liable to mistake lithia for magnesia, and strontian for lime; but lithia and strontian

occur in mineral waters very rarely, and in very small quantities.

Detection of Potash and Soda. Concentrate the mineral water by evaporation, mix the liquid with an excess of a solution of carbonate of ammonia, separate the precipitate by filtration, evaporate the clear solution to dryness, and expose the dry residue to a red heat in a platinum spoon. The product contains the alcali sought for. Mineral waters commonly contain soda; the occurrence of potash is more rare. The method of distinguishing potash from soda has been fully described at pages 50 to 52.

Detection of Sulphuric Acid. Slightly acidulate the mineral water with muriatic acid, and add a solution of chloride of barium. The production of a white precipitate, which cannot be dissolved by diluted acids, demonstrates the presence of sulphuric acid.

Detection of Muriatic Acid and of Chlorides. To another portion of the mineral water, add a little nitric acid, and then a solution of nitrate of silver. The production of a white precipitate is an indication of the presence of muriatic acid or of chlorine. Yet this experiment is liable to certain fallacies. If sulphuric acid is present, a white precipitate of sulphate of silver may be produced. I have shown (p. 60), how this ambiguity may be avoided. Farther, if a solution contains iodine or bromine, it gives a white precipitate with a solution of nitrate of silver,

even when no chlorine is present. Both iodine and bromine, however, occur in mineral waters very rarely, and in very small quantities.

Detection of Sulphuretted Hydrogen. The presence of sulphuretted hydrogen, or of metallic sulphurets, in mineral waters, is detected by the odour of rotten eggs, by which such waters are characterised. It is also detected by the black precipitates which are produced when the waters are mixed with solutions of nitrate of silver and nitrate of lead. A mineral water which contains sulphur cannot be tested for chlorine till the sulphur has been removed. In such a case, you must mix the mineral water with a solution of sulphate of copper. This produces a precipitate of sulphuret of copper. You separate this precipitate by filtration, acidulate the filtered solution with nitric acid, and then proceed as directed in the preceding paragraph.

Detection of Carbonic Acid. To a portion of the mineral water, fresh-drawn, and not concentrated by evaporation, add a small quantity of lime water. If the water contains carbonic acid a white precipitate will be produced. When a mineral water is strongly effervescent, it indicates the presence of a considerable quantity of carbonic acid.

Detection of Silica. This occurs in almost every mineral water. It is detected by evaporating the water to dryness without any pre-

vious filtration. I have described the process at page 175.

Organic Remains. When mineral waters are strongly concentrated by evaporation, they become yellowish, and when the dry salts produced by the evaporation are gently ignited, they blacken, These changes are owing to the presence of various organic substances in the waters.

Distilled Water. It must have no smell, taste, or colour. It must evaporate from a watch glass or platinum foil without leaving a residue. It must give no precipitates with solutions of nitrate of silver, chloride of barium, superoxalate of potash, caustic alcalies, carbonated alcalies, sulphuretted hydrogen, or hydrosulphuret of ammonia.—*Rain Water.* It generally contains carbonic acid, carbonate of lime, and chloride of calcium.—*Spring Water.* It contains the same impurities as rain water, superadded to chloride of sodium, sulphate of lime, carbonate of iron, &c.—*River Water.* More free from salts than spring water, but often contains a large quantity of decomposing vegetable and animal matters. This is particularly the case with water taken from the Thames near London.—*Lake Water.* All descriptions of stagnant water abound in half-putrified organic remains. The smaller the bulk of the liquid (as in the case of a marsh), the more impure and the more unwholesome it is.

To clarify muddy Water. Add to it a solution of alum, in the proportion of a few grains of the salt to a pint of the water.—*To soften hard Water.* When the water contains lime in combination with carbonic acid, it can be softened by continued boiling, which expels the excess of carbonic acid, and permits the carbonate of lime to precipitate. When the lime is united to sulphuric acid, the water must be mixed with a solution of subcarbonate of potash, or purified pearlashes. The mixture should be stirred, and left to repose twenty-four hours, after which the water may be poured from the sediment. In this case carbonate of lime precipitates, and sulphate of potash remains in solution. This salt is not unwholesome, nor is it hurtful to water intended to be employed in the laundry or the kitchen. The quantity of the solution of carbonate of potash necessary to be added to the water to be corrected, depends upon the degree of impurity of the water. When the clear water gives no new precipitate on being mixed with a little more of the solution of carbonate of potash, it has been mixed with a sufficient quantity of that liquid.—*To correct the putrid Smell of stagnant Water.* Agitate it with a small portion of magnesia, or with the hundred-and-fiftieth part of its weight of peroxide of manganese, or with a little animal charcoal, and separate these substances by filtration.—*To preserve Water from Putrefaction.* Keep it in vessels of iron, or of wood charred within; or dissolve

lime in it, and separate the lime when the water is wanted, by passing a current of carbonic acid gas into the cask.

Medicinal Mineral Waters.—They may be divided into four classes. (*a*) *Acidulous Waters.* These contain free carbonic acid, supercarbonates of lime, magnesia, soda, &c.; also, chloride of sodium, sulphate of soda, sulphate of magnesia, and sometimes carbonate of iron. (*b*) *Chalybeate Waters.* They contain the same constituents as acidulous waters, superadded to a pretty large proportion of carbonate of iron. (*c*) *Saline Waters.* Their principal constituent is sulphate of magnesia, but they also contain chloride of sodium, sulphate of soda, bicarbonate of lime, bicarbonate of magnesia, and, when fresh-drawn, a portion of free carbonic acid. (*d*) *Sulphurous Waters.* They derive their character from the presence of sulphuretted hydrogen, or sulphur combined with the metals of the earths and alcalies. The sulphurous mineral waters which redden litmus paper, contain sulphuretted hydrogen; those which turn reddened litmus blue, contain alcaline sulphurets.—If a mineral water is presented to you for analysis, it will be easy, by following the foregoing rules, to ascertain to which class it belongs.

Adulterated Mineral Waters. Acidulous waters, when bottled for sale, are often mixed with mineral acids, because they are esteemed in proportion to their acidity. This cheat is detected by the permanent red colour which the water gives to litmus paper, and by the

fact that the water remains acid after having been boiled, which it ought not to do. Chalybeate waters are strengthened by the addition of sulphate of iron. This falsification is detected by boiling the water, and then filtering and testing it for iron. If the mineral water is genuine, it will contain no iron after having been boiled; but if sulphate of iron is present, it will be indicated by the tests.

WAX.—*Yellow Wax.* — Good and recent yellow wax has a slight odour of honey, is insipid to the taste, and of a bright pale yellow colour. It is brittle, yet soft, can be easily moulded between the fingers, is somewhat unctuous to the touch, but neither adheres to the fingers, nor to the teeth when chewed. Its texture is granular. In the preparation of wax for sale, the honeycombs of the bees, previously freed from honey, are melted, at a gentle heat, with a small quantity of water, and the melted wax is run into moulds adapted to give it a certain form. As the wax cools, it deposits a variety of impurities, which are cut from the bottom of the cake by a knife. The mass of impurities is called the *foot*. When you purchase wax, you should break each cake, in order to ascertain that it does not consist of a *foot* encased in a thin shell of pure wax. The substances generally employed to adulterate wax are resin, tallow, earth, peasemeal, potatoe-starch, and a mixture of oil and litharge. *Earth*, or *peasemeal*, may be suspected when the cake is very brittle and the colour inclines

more to gray than to bright pale yellow; these substances may be separated by re-melting and straining the wax. The presence of *resin* may be suspected when the fracture appears smooth and shining, instead of being granular; and it may be detected by putting small pieces of the wax into cold alcohol, which will readily dissolve the resinous part, but not act on the wax. *Tallow* is discovered by the greater softness and unctuosity of the cake, and by the disagreeable suffocating odour which it exhales on being melted. *Potatoe Starch* is detected by digesting the suspected wax in spirit of turpentine, at a gentle heat. The wax dissolves entirely in this liquid, but the starch remains behind. Wax which contains starch has generally a dull yellow colour, and is much heavier than wax of a good quality. The wax which is adulterated with a plastic mass, formed of *oil and litharge*, is, in all probability, not a very frequent article of commerce. It may be known by its greater comparative weight, and by instantly assuming a black colour on being moistened with liquid sulphuretted hydrogen.

White Wax. This is sometimes adulterated with *carbonate of lead*, in order to increase its weight, and with *white tallow*. The former is detected by melting the wax in water, when the salt falls to the bottom of the vessel, or by moistening the adulterated wax with liquid sulphuretted hydrogen, which turns it black. The *tallow* is detected by the dull white colour, and the opacity which it

communicates to the wax. Another adulterant added to white wax is *spermaceti*. The mixture is more opaque and softer than pure wax, and the surface of the cake exhibits a peculiar mottled appearance. It is also more easily fusible than pure wax.

Wine.—Although wines are the natural product of the spirituous fermentation of the grape, and are composed of the same ingredients united in proportions which vary but slightly, they nevertheless are endowed with properties which differ considerably. These differences are due, partly to the variations of climate, soil, and season, and partly to the mode and duration of the fermentation of the grapes. Most generally, such differences in the natural properties of wine are more easily distinguished by the taste and odour than by any chemical re-agents. Analysis, indeed, can determine the relative proportions of alcohol and water, of sugar, tartar, and salts contained in different kinds of wine, but still the elements upon the presence or particular combinations of which the excellency of certain wines depend, are precisely such as escape the indication of chemical tests. Tasting, therefore, is the best and only general method of determining the value and quality of wines.

The wilful adulteration of wine is practised much less frequently than is commonly supposed, but in all cases where it is practised, it is much easier to detect it by chemical tests than by the taste. The adulteration of wine is reduced to the addition of a small number

of substances, destined either to neutralise the acetic acid of wine, or to augment the intensity of its colour. I do not consider as adulterated wines the liquors produced by the mixture of different wines one with another. Such compounds are generally intended to be drank within a short space, and they are not chargeable with being injurious to the animal economy. The quality of such wines is to be judged of by the taste alone.

Wines sweetened by Alcalies.—A multitude of circumstances tend to the production of acetic acid in wine, which is thereby rendered *sour* and unsaleable. Merchants are accustomed to neutralise the acetic acid contained in their wines by the addition of various alcaline substances, such as the carbonates of lime, potash, and soda. Wines which have undergone this species of adulteration are almost always harsh and disagreeable to the taste, notwithstanding that they are in general freshened by the addition of a quantity of brandy.

Detection of Lime.—When carbonate of lime is employed to correct the acidity of wines, the sweetened wine retains acetate of lime in solution. The best method of detecting the lime is as follows:—add liquid ammonia to the wine until it is rendered alcaline, then add a solution of commercial superoxalate of potash. If lime is present, a precipitate of oxalate of lime is formed. This precipitate often possesses a very dark colour when produced under the above circumstances, although its natural colour is white. It is necessary to

analyse the precipitated oxalate of lime, in the manner described (pp. 46 and 129). There is one circumstance which requires to be particularly attended to in this analysis. Pure wines often contain small portions of sulphate and tartrate of lime, both of which salts are capable of affording a precipitate with solutions of superoxalate of potash. But the precipitate produced by this re-agent in pure wines is scarcely visible, while that which is produced in adulterated wines is very abundant. To get quite free from ambiguity, it is proper to proceed as follows:—Evaporate a portion of the wine to one-eighth of its original bulk and add to the residue twice its bulk of alcohol, by which a precipitate of tartrate and sulphate of lime will be produced; filter the solution and evaporate it to dryness; dissolve the dry residue in distilled water, which will give a solution containing the acetate of lime produced by the adulteration of the wine. This solution is to be tested for lime by the addition of superoxalate of potash in the manner already described.

Detection of Potash.—When carbonate of potash or pearlash has been employed to correct the acidity of spoiled wine, the wine retains acetate of potash in solution. This salt may be detected as follows:—Evaporate the wine in a Wedgewood's-ware basin over a lamp or slow fire till it produces a dry extract. Let the vessel cool, add a small quantity of alcohol, filter the solution and submit it to the tests described at p. 50.

Detection of Soda.—Evaporate the wine to dryness as described in the process for the detection of potash. Put the dry extract into a small crucible and calcine it. Then proceed in the manner described at p. 51.

Wine sweetened by Litharge.—The employment of litharge in the neutralisation of the acid of wine, is a fraud of long standing. It was much more frequently practised formerly than it is now, partly because its injurious action on the human body was less generally known, partly because the wine-doctors were then in less danger of detection than they are now. BRANDE tells us that in numerous samples of wine of suspected purity which he had occasion to examine, he never found any poisonous ingredients which could be traced to direct adulteration. He accounts for the presence of minute quantities of lead in some wines by attributing it to shot in the bottles; and states that, of common wines, Madeira is most liable to contain lead, because it is a wine of superior acidity, and therefore endowed with the property of dissolving metallic lead with more facility than many other wines. In one instance, he detected arsenic in a bottle of sherry, but it was confined to the single bottle and traced to a cattle-lotion which it had previously contained. This circumstance is sufficient to show that the prevalent custom of putting wine into washed bottles which had not previously contained it, is exceedingly dangerous.—The methods of detecting the presence of lead in wine have

been fully explained in the article on lead at p. 8.

Artificial Colouring of Wine.—It is a common opinion in different classes of society that most red wines owe their colour to the addition of foreign dyes; and the generality of authors who have written upon wines, have in no slight degree helped to support and propagate this opinion by the citations they have made of a multitude of colouring substances employed for this purpose. Logwood, Brazil wood, red sanders, beet-root, and many other substances, are stated to be in constant use as colouring matters in every wine cellar. But it is difficult to believe that wine-merchants introduce into their cellars a multitude of substances, the discovery of which would not only compromise their reputation and fortune but expose them to correctional fines, when the object of colouring light wines can be easily and safely effected by a slight addition of some of the dark-coloured varieties produced by the vineyards of Languedoc, Roussillon and many other parts of the south. That most gross adulterations of wine are occasionally effected by ignorant and unprincipled dealers, it would be in vain to deny; but I do not believe that the practice of giving a factitious colour to pale wines, otherwise than by the addition of dark-coloured wines, is at all common; and even in those cases where colouring substances are actually added to wines, the probability is, not that they are solutions of the woods above-mentioned, but

the juices of certain berries which possess not merely the requisite deep colour, but a vinosity which qualifies them to be mixed with wine without injuring its flavour. In reality, it is a practice in some districts of Champaign, to prepare a liquor for the especial purposes of colouring wines, by fermenting the juice of the berries of elder, privet, blackberries, and sloes.

It is difficult to detect the presence of artificial colouring matter in wines. The great analogy which exists between the colouring matter of genuine wines and that of the substances mentioned above, and still more, the variations occasioned in the properties of the natural colouring matter, by the climate and the mode of preparation of the wines, render the results of all experiments which might be made to distinguish them, extremely doubtful; so much so, indeed, that scarcely any confidence is to be placed in the processes which have been published for the discrimination of pure wines from such as have been coloured artificially. The colours of the precipitates occasioned by various re-agents differ so little from each other, and are so difficult to appreciate, that one might be led into the commission of a great number of errors, were an exclusive confidence given to this mode of trial; this will appear the more evident if it is considered that the wines of which the colour is deepened by artificial means, always contains a certain proportion of natural colouring matter, the presence of which must neces-

sarily tend to throw additional uncertainty over the results of one's experiments.

Wines strengthened by Spirits.—As the persons who drink much wine generally reckon it so much the better in proportion as it contains a greater quantity of alcohol, it is a common practice to strengthen flat and poor wines by the addition of brandy or spirits of wine. Mixtures of this kind are often very capital, being sometimes made sufficiently strong to inflame when thrown in the fire. When recently prepared, they may be detected by good judges of wine, for the mixture is destitute of that softness and richness of taste which characterises natural wine. But when the mixtures are old, their discrimination from genuine wine is next to impossible, either by the taste or any other test.

Experimental Estimation of the Strength of Wines.—It is not possible to determine the proportion of alcohol contained in wines, by means of the hydrometer. This instrument affords trust-worthy indications only when made to act in mixtures of pure spirit and water. Foreign matters in solution impede its action. (See pp. 79 and 152.) When plunged successively into different wines, it ought to sink deepest in that which is the most generous; and if all wines were equal in composition and differed only in their *per centage* of alcohol, the hydrometer would afford very useful comparative results. But the presence of sugar and salts in wine has the effect of rendering the indications of the

hydrometer altogether fallacious. Certain sweet and rich wines have, for example, nearly the same specific gravity as water, and yet contain fifteen or eighteen *per cent.* of alcohol; whereas many strongly fermented wines, such as those of Burgundy, are often much lighter than water, though they contain not more than ten or eleven *per cent.* of alcohol.—The best way to determine the quantity of alcohol contained in a given sample of wine, is to separate it from the non-volatile constituents by distillation. A very neat apparatus for experiments of this nature has been contrived by M. Gay-Lussac; but any species of small still or retort may be employed for the purpose. You take three hundred parts of the liquor to be tried, measured in a graduated glass tube. The operation is equally adapted for wines, beer, gin, and all kinds of spirituous liquors. Having inserted the liquor into the still, you carefully and slowly distil over one hundred parts, or one-third of the liquor in the still, making use of a graduated tube as the recipient, and stopping the operation when the distilled liquor reaches the hundredth degree. You then ascertain the alcoholic strength of the distilled liquor by means of the hydrometer (p. 79); and, dividing the result by three, you have at once the *per centage* of alcohol of the liquor submitted to examination. If, for example, the hundred parts of distilled liquor contain thirty parts of alcohol, the wine submitted to distillation contains ten *per cent.* of alcohol. But if, from want of

attention, you distil over more than one hundred parts of the liquor, it will not do to divide the alcoholic strength of the product by three, to obtain the *per centage* of alcohol of the liquor submitted to distillation. You must employ as the divisor, the number which expresses the relation of the volume of the distilled product to the bulk of the wine. If, for example, you have one hundred and six parts of distilled liquor, containing (as ascertained by the hydrometer) thirty-three parts of alcohol, you divide three hundred by one hundred and six, which gives 2·83, and then divide thirty-three by 2·83, which gives 11·66. This last number expresses the *per centage* of alcohol of the liquor submitted to examination.

If you do not possess a hydrometer, you may ascertain the proportion of alcohol contained in a mixture of alcohol and water, by the process which follows:—add to the liquor, contained in a graduated tube, small portions of pure subcarbonate of potash, previously heated to redness in a platinum crucible. When a portion of the salt remains undissolved at the bottom of the liquor, the operation is finished. You will then perceive the alcohol floating above the aqueous solution of potash, and by means of the scale on the tube, you can ascertain how many parts of alcohol are disengaged from one hundred parts of the mixture of alcohol and water.

Zinc.—Zinc, heated till it sublimes, must inflame and produce a perfectly-white oxide. If the colour of the oxide is red, the zinc con-

tains iron. It must dissolve without residue in sulphuric acid, otherwise it contains lead, cadmium, or charcoal. The common zinc of commerce generally contains these substances. It must also dissolve completely in nitric acid. The solutions must be colourless, and must give white precipitates with solutions of caustic potash, carbonate of ammonia, and caustic ammonia, which an excess of potash or of carbonate of ammonia must re-dissolve. If there is any insoluble residue, the zinc may contain iron, lead, or cadmium. If the residue has a yellowish-brown colour, it indicates the presence of iron. If it is white and re-dissolves in a considerable excess of caustic potash, but not in carbonate of ammonia or caustic ammonia, it indicates lead. But this can be found only in the nitric acid solution, for when zinc is dissolved in sulphuric acid, the lead precipitates in the state of white sulphate of lead. If the precipitate is white, soluble in ammonia, but insoluble in potash, and in carbonate of ammonia, it contains cadmium.—The white precipitate must be lemon-yellow when heated, but become white when cold. If it continues yellow, it indicates the presence of lead; if reddish-brown, of iron; if orange-brown, of cadmium; if dark brown, of copper. The solution of zinc, previously acidulated, must give no precipitate with liquid sulphuretted hydrogen. If it becomes black, it contains lead or copper; if yellow, cadmium. With hydrosulphuret of ammonia, it must give a perfectly white precipitate. If the pre-

cipitate is blackish, and the acidulated solution gives no precipitate with liquid sulphuretted hydrogen, there is no doubt of the presence of iron.—The neutral solution, on being tested with a solution of yellow prussiate of potash, must give a white or pale yellow precipitate. If the precipitate has a reddish colour, it indicates copper, if blue, iron.—When zinc contains arsenic, the hydrogen gas which is disengaged during its solution in acids, possesses an extremely fetid odour, attributable to the presence of arseniuretted hydrogen. The smell of this gas is poisonous.

ZINC, *Oxide of. Flowers of Zinc.*—It ought to be perfectly white, should become lemon-yellow when heated, and regain its whiteness when it cools. If it is reddish-brown, it contains iron; if yellow, cadnium.—It must dissolve completely, and without effervescence, in diluted sulphuric acid. If it effervesces, it contains carbonate of zinc, or perhaps chalk or white lead. If it leaves a residue, it contains chalk or white lead. If the precipitate turns black when moistened into liquid sulphuretted hydrogen, it is probably lead; if it remains white it is lime. Sometimes, however, a little silica is deposited during the solution of oxide of zinc in acids. This may be distinguished by employing nitric acid, which dissolves the chalk and white lead, but not the silica. The solution of oxide of zinc may be tested for other impurities, like the solution of metallic zinc.

Oxide of zinc has sometimes been found to

contain arsenic. The presence of this metal may be detected in the solution of the oxide of zinc, by the process given at page 23.

Zinc, *Sulphate of. White Vitriol.*—This salt, especially when bought in irregular masses, free from water of crystalisation, is apt to contain copper and iron. Dissolve the salt in water, and add an excess of liquid ammonia to the solution. The zinc will be wholly re-dissolved, the copper will dissolve and produce a blue solution, the iron will precipitate in the form of a brown powder.

THE DOMESTIC CHEMIST.

PART III.

A Popular Introduction to the Art of Chemical Analysis.

ALTHOUGH I have taken pains to render the foregoing instructions as precise and intelligible as possible, I am yet aware that persons who are unpractised in chemical manipulation, may meet with difficulties in attempting for the first time, to reduce some of the more refined operations to actual experiment. I shall therefore add a *third part* to the "DOMESTIC CHEMIST," to gain an opportunity of detailing that practical information which beginners in chemistry stand so much in need of. What I think it necessary to say here, I shall arrange under three heads. In the first place, I shall describe the most important chemical operations, with the vessels which are to be employed, and the precautions which are to be taken, to render the performance successful. I shall then give a few general rules to guide the experimenter in his earlier essays.

And finally, I shall describe the methods of preparing, of husbanding, and of employing the various tests or re-agents which it is necessary to make use of, in attempting to discover the poisons, adulterants, and impurities, whereof I have treated in the preceding pages.

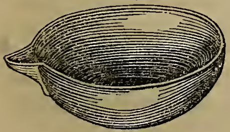
I. *Chemical Manipulation.*

Reduction of Solids into Small Fragments.—When solid bodies are to be subjected to the action of liquids, they must be first reduced to small fragments. If they are soft, like bread, pickles, pudding, and most other organic substances, they can be cut to pieces with a knife, or rubbed to pap in a mortar of Wedgewood's-ware. If they are brittle, like salts, stones, &c., they may be pulverised by means of a pestle and mortar, or if the latter is not at hand, the salts may be wrapped in paper and crushed by a hammer. Certain experiments, in which salts are ignited with charcoal and soda, to produce particles of pure metals (p. 6), require the aid of a small mortar of agate. This need not be more than one and a half inch in diameter. Such a mortar costs about half-a-crown in Paris, but in London, a much larger sum must be given. It is, however, an indispensable instrument for such as wish to accustom themselves to make experiments with the blowpipe.

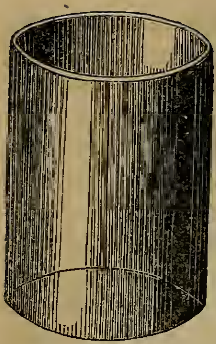
Solution.—When you put a solid into a liquid, and the solid disappears, leaving the

liquid quite transparent, which, for example, is the case when you put common salt into water, you perform the operation of solution. This is generally performed for the purpose of placing the substance operated upon in a state fit for chemical action. You must be provided with a variety of vessels for performing the operation of solution, a few of which I shall now describe.

The figure represents a Florence flask, which being made of thin glass, bears the sudden application of heat without breaking. A solution can be readily boiled in a flask over a lamp or charcoal fire. The flasks may be bought of oilmen, for about a penny each. They contain nearly a pint.—Wedgewood's-ware capsules,



from one and a half inch to three inches in diameter, and furnished with a lip, are very useful vessels for solution and evaporation. They bear heat without breaking, and are not acted upon by acids. They cost from threepence to two shillings each.—The following figure represents a vessel of great use, not only in solution, but in many other chemical operations. It is a simple glass cylinder, without foot, or rim, or ornaments of any kind. Tumblers frequently answer the purpose,



but what are known in the glass-houses by the name of confectioner's glasses are preferable, because, being less thick at the bottom, they are less liable to break when exposed to heat. The small kinds, from half an ounce to half a pint in capacity, are most useful in qualitative analysis.

The figure represents a sort of phial which is much employed by French and German chemists. It is made of thin green glass, which withstands equally well the action of heat or of acids. The bottom is turned a little inwards, so that it can stand alone without support, and is made thin so that it can be exposed to a naked fire. Vessels the size of the figure, are very useful for effecting the solution of small portions of a substance.

Extremely useful vessels for solution, especially when the operation is to be effected with the aid of heat, can be readily made of thin glass tubes.* The subjoined diagrams exhibit the forms of such vessels.

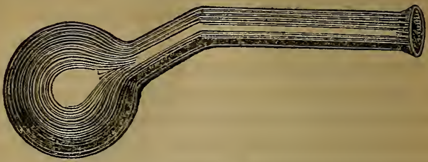
* Full instructions for the construction of tube-vessels for chemical experiments, are contained in the

This represents a tube of thin glass, closed, rounded and well annealed at one end, and widened a little at the other, which is open. The smallest tube of this kind should be one-fourth of an inch in diameter and one inch and a half long, and the largest about five inches long and five-eighths of an inch in diameter. This is the kind which is best adapted to be generally used as test tubes, though tubes of the size of the above figure may be employed for the same purpose. The following figure represents a tube of the size of a quill, with a bulb blown at one end, so as to constitute a small matrass. Glasses of this kind may be used when a substance is to be heated over a

lamp with a view to ascertain whether it contains water, which, if present in the solid matter, is sublimed and condensed on the inner surface of the narrow part of the tube. The next figure is a tube of the same descrip-

" Art of Glass-Blowing," which forms Vol. I. of the " Polytechnic Library."

tion, with a round bulb at one end, and a bend



near the bulb, the object of which arrangement is to produce a small retort. If you intend to make many analytical experiments, you ought to be provided with a great variety of glass tubes, and particularly of the straight sort, or *test tubes*, first described.

When the solution of small portions of matter is to be effected with the aid of heat, or when solutions of small bulk are to be evaporated, it is customary to employ watch glasses. But an instrument which almost supersedes the use of small capsules of glass or porcelain, is a capsule of platinum, furnished

with a small flat handle of the same metal. The figure represents the full size of the capsule. The cost of such a capsule, when purchased of Mr. Carey, in the Strand, London, or any other dealer in platinum, is about eight shil-

lings. It is an extremely useful instrument in analytical chemistry, and though high in price, soon pays its cost, by the great number of glass vessels it saves from destruction. Solid bodies may be heated red hot in it. You have only to take care not to put into it such substances as can disengage chlorine, and not to ignite it with substances which can yield reguline metals, otherwise it will be destroyed.

NEUTRALISATION.—There are certain liquids which have the property of changing the colour of *litmus test paper* from blue to red; such liquids are said to be *acid.* There are other liquids which change the colour of *turmeric test paper* from yellow to brown; such liquids are said to be *alcaline.* When an alcaline liquid is added to an acid liquid in a certain proportion, the *mixture* has no effect in the colour either of litmus or turmeric. The mixture is then said to be *neutralised.* But if an alcaline liquid is added to an acid liquid, in greater quantity than is barely sufficient to *neutralise* the acid liquid; in other words, if an *excess* of the alcali is added to the acid, then the liquid which was originally acid becomes alcaline, that is to say, it acts like an alcali, in virtue of the excess of alcaline liquid which it contains. Whenever any acid liquor, such as the vinegar of pickled cucumbers, is to be tested for copper, such a quantity of ammonia is to be added as is sufficient, not merely to neutralise

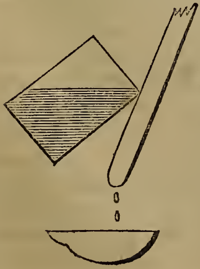
the acid, but to render the liquid alcaline, because the alcali (*viz.* the ammonia) exhibits no action on copper in the presence of free acid (see p. 2). But you will ask, how is the acidity or alcalinity of a liquid to be ascertained? The answer is, by means of the test papers. Every liquor which reddens litmus contains an excess of acid; every liquor which renders turmeric brown, or turns reddened litmus blue, contains an excess of alcali. Hence these test papers are of considerable service in chemical experiments. In trying the neutrality of a liquid, you may either dip the end of the test paper into the liquid, or touch the test paper with a glass rod dipped in the liquid; the latter is the cleanest method.

TESTING.—The liquid to be tested should be put into a small wine glass, or into one of the test tubes described at page 283. A very small quantity of the liquid is sufficient. You may take three or four drops if the liquid is scarce, or as much as fills half an inch of the tube, if it is abundant. The tests to be applied are generally in a liquid state. You must add them in very small quantity. When a test is very sensible in its indications, you may dip the end of a clean glass rod into the liquid test, and then stir the liquid in the test tube with the same end of the rod. Thus you may dip a glass rod first into sulphuric acid and then into a clear solution containing barium. You will immediately observe the formation of a white precipitate of sulphate

of barytes. When the test is less sensible, you must add one or two more drops to the liquid, according to the effect intended to be produced. On some occasions it is necessary to add a considerable quantity of the test, in order to re-dissolve the precipitate which it produces on being added in small quantities (page 145). It is always improper to add the test liquid in large quantity at first. You must invariably drop it in gradually.

Flat plates of glass are very useful where extremely small quantities of a liquid are to be tested. The unknown liquid is applied to the glass in drops by means of a glass rod, and the test is added to it in the same manner.

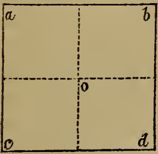
Decantation.—If you wish to remove a liquid from a powder which has subsided in it, or if you want to pour a liquid from a large-mouthed vessel into a small-mouthed vessel, you may proceed as follows:—Apply a little tallow to the edge of the large vessel, hold the middle of a glass rod against the tallow, and then, by inclining the large vessel, make the liquid run gently down the rod into a vessel placed below the point of the rod to receive it. The tallow prevents the liquor from running down the outside of the large vessel. You must perform this operation with-

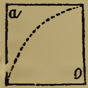


out losing a single drop of the liquid. If you want to convey a small quantity of any liquid out of one vessel into another, you employ a glass tube, having a fine point at one end and a bulb in the middle. You put the narrow point into the liquid, and then suck the liquid into the bulb with your mouth; you then close the upper orifice of the tube with your tongue, remove the point of the tube into the proper vessel, and then, by opening the upper end of the tube, permit the liquid to run out. The tube should be twice as large as the figure. A small tube without a bulb may be employed when very small quantities of liquid are to be transvased, as, for example, in the application of chemical tests. The liquid ascends in sufficient quantity by capillary attraction, and can be easily blown out of the tube. Take care, in sucking acids and alcalies into a tube, not to suck them into your mouth. I once sucked caustic potash into my mouth, and did not like the relish of it.

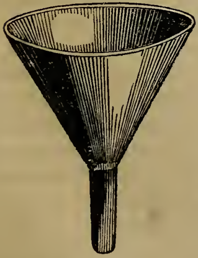
Filtration.—When a solution has been prepared for examination, it ought to be perfectly transparent. If it appears muddy or troubled it must be filtered through a paper

filter, by which means it is separated from the solid matters which make it appear opaque.



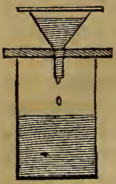


Take a piece of white blotting paper, about two inches square; fold it in half, so as to bring the corners *c d* upon the corners *a b;* then fold it again, so as to bring the four corners together at *a;* cut off the corners, so as to form a quadrant, in the manner shown in the under figure *a o;* and, finally, open the first fold, so as to produce an inverted hollow cone. The letter *o* points out the position of the centre of the paper in all the figures. Procure a



glass funnel, of the size and form of the annexed figure. This is large enough to hold most precipitates which occur in qualitative experiments. Very often smaller funnels, made of tube, are useful, and sometimes large funnels are necessary. They must always be made of glass. The paper filter, folded in the manner described above, is exactly formed to fit a funnel of this shape. But the English funnels are generally narrower and longer than this figure, and such funnels are extremely

objectionable. The filter, when placed within the funnel, must not come within an eighth of an inch of the top, otherwise the liquid which may be poured into it is liable to run over.



The neck of the funnel should be placed through a hole made in the middle of a square piece of thin board, or of stout pasteboard, and the board should be laid on the top of the glass cylinder intended to receive the filtered liquor. When the access of atmospheric air is to be avoided, the funnel must be covered with a plate of glass, and if the air is to be utterly excluded, the edge of the funnel and the surface of the glass plate must be ground. When the filtering apparatus is placed together, in the manner shown by the last wood-cut, the liquor to be filtered is to be decanted into the paper, with the help of a rod, as described in the article on "Decantation" (p. 287). The liquor should never be permitted to rise quite to the top of the paper filter, otherwise it will escape between the paper and the glass, and then run down into the clear liquor, and oblige you to perform the whole operation over again. The fuller you keep the filter, however, the quicker the filtration proceeds. Keep it therefore nearly full, but do not let it run over.

If you wish to filter broth, or any mixture containing animal matters, first run it through muslin to clear it of the heaviest part of the

solids it contains, and filter it through paper afterwards.

PRECIPITATION.—When two limpid solutions are mingled together, and chemical action is excited, the whole mixture often becomes turbid, and a solid powder, in a state of extreme division, falls to the bottom of the vessel. This powder is called a *precipitate,* the agent employed expressly to produce it, is called a *precipitant,* and the operation which causes its production is called *precipitation.*

Precipitation is extensively employed in analytical chemistry. In qualitative analysis it is used to demonstrate the presence of certain bodies in solution; and in quantitative analysis, it is employed to separate the bodies contained in a solution from one another.

The best vessels for precipitation in qualitative analysis are *test tubes*, formed of white glass, five inches long, and about half an inch in diameter. You should be provided with a considerable number of these tubes, and a stand to hold them, such as will be described in a subsequent paragraph.

In quantitative analysis, where the precipitates are often of considerable bulk, the best vessels for precipitation are plain cylindrical glasses, such as the confectioners' glasses, described at page 282. They should be of various sizes. It is useful to have a few with the edges ground smooth on a stone. These

can be closed air-tight by the application of a piece of ground plate-glass. This is very necessary in certain operations, in which the exclusion of atmospheric air is indispensable to the success of the operation.

Precipitation is sometimes promoted by the presence of alcali or acid in excess. This depends upon the properties of the particular substances which are operated upon. It is in general promoted by agitation, and still more by heat. When the application of heat is absolutely necessary, the operation is sometimes best performed in a porcelain or platinum capsule, or in a florence flask. Occasionally, the solution is first heated, and then mixed with the precipitant; in other cases the solution is warmed after the precipitant is added: this is done to make the precipitate fall down properly, and become fit for filtration. Rose, in his work on "*Analytical Chemistry*," describes particularly the cases in which the one or the other of the above methods is to be followed. The presence of vegetable matter in metallic solutions often hinders the formation of precipitates, which would otherwise be produced. For precise information on this point I refer you to Rose's book, cited above.

If you have a substance in solution, and wish to precipitate it entirely, you may proceed as follows:—Add a small quantity of the precipitant, mix it well with the solution by stirring it with a glass rod, and then allow the whole to settle. As soon as the upper

part of the solution has become clear, add a single drop of the precipitant. If this causes a troubling, add a little more of it. Stir the whole well together, allow it to settle again, and then test it afresh with another drop of the precipitant. Proceed thus until the addition of a single drop of the precipitant causes no opalescence in the supernatant liquid. Towards the end of the operation, the precipitant should be in a dilute state, provided it be of importance that no excess of it should be added to the solution. It is extremely difficult to hit the exact point of neutralisation—to add precisely enough of the precipitant, without adding too much. In general, precipitation is most completely effected when a slight excess of the precipitant is added to the solution; though sometimes the effect produced by adding an excess of the precipitant is the re-solution of the precipitate. When, however, the precipitant is cheap, does no harm to the precipitate, and is not injurious to the resulting solution, it is advisable, rather to effect the precipitation by adding an excess, than to lose time by delicately attempting to effect an exact neutralisation.

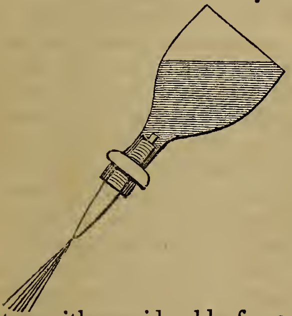
Edulcoration.—After having precipitated a substance, it is generally necessary to effect a complete separation of the precipitate from the solution. You must allow the precipitate to subside. It sometimes falls down

very slowly; sometimes very quickly: in general, the subsiding is facilitated by gently warming the solution. In the meantime, you prepare a filtering apparatus, like that depicted at page 290, and when the supernatant solution is clear, you decant it into the filter, taking the precaution of not disturbing the precipitate. When the clear liquor has nearly all passed through the filter, you stir up the residue with the precipitate, and bring the whole upon the filter, washing out the vessel with a little distilled water, and pouring the washings over the precipitate. When the precipitate adheres to the glass, so that it cannot be removed by the glass rod, you must rub it off with a clean feather, or with the end of your fore-finger, which must previously be washed very clean, and the precipitate on which must be carefully washed off by means of the edulcorator, an instrument of which I shall speak presently.

When the liquor has all run through the filter, and left the precipitate in a comparatively dry state, it is still necessary to free the latter from the portion of the solution with which, being a very spongy mass, it must necessarily remain impregnated. You effect this by washing it with distilled water, by the help of an *edulcorator,* or washing-bottle.

The edulcorator is a bottle of the description represented by the figure in page 282. Its mouth is closed by a cork, through which a short piece of strong glass tube is

passed. The cork must fit the bottle very tight, and the external orifice of the glass tube must be very small, never exceeding the fortieth of an inch in diameter. The bottle should be rather more than half full of distilled water. If you hold the edulco-



rator with the cork downwards, and then put the point into your mouth, and blow air into the bottle, the water, upon your removing the point from your mouth, will, for a few moments, be expelled from the edulcorator with considerable force. It passes out in a fine stream, which can be directed upon the precipitate in the filter so as to stir it up and wash it with great ease and effect. Towards the end of the edulcoration, the jet of water should be directed towards the edges of the filter, and not upon the precipitate itself, by which means the precipitate is washed down to the bottom of the filter, and brought into a small compass. Precipitates of a gelatinous consistence require much washing. The jet of water is sometimes destitute of sufficient force to stir them up. In this case you may stir them with a small glass rod with a round end; but you must be exceedingly careful not to force the rod through

the filter, otherwise the filtration will have to be repeated.

The edulcoration must be continued until the precipitate is completely freed from the solution in which it was produced. This is the case when the liquid which drops from the neck of the funnel consists of pure water alone. You take a drop of liquid from the neck of the funnel upon a bright piece of platinum foil, and evaporate the liquid to dryness. If it leaves no residue it is pure water; if it leaves a stain, it still contains fixed matters, and the edulcoration must be continued. If the solution which runs through the filter contains sulphuric acid, muriatic acid, barytes, silver, or any other substance for which you possess a re-agent which acts as a very delicate precipitant, you may collect a drop or two of the liquid at the neck of the funnel, and test it with that particular re-agent. In this case you continue the edulcoration until the washings give no precipitate with the said re-agent.

It is scarcely necessary to inform you, that the neck of the funnel must never be allowed to dip into the filtered solution, for, otherwise, the liquor which runs from it can never be collected for testing.

SOLUTION OF PRECIPITATES.—It is frequently necessary to re-dissolve the solid compounds produced by precipitation, in order to subject them to the action of additional tests. The precipitates are gently dried on the filter

till they acquire the consistence of soft dough, and are then removed from the paper, and put into the liquid in which it is intended to dissolve them. But when the precipitate is very small in bulk, or sticks very closely to the filter, or is much spread over the surface of the paper, it is often advisable not to attempt to separate it from the filter, but to expose it, paper and all, to the action of the solvent. It very seldom happens that the constituents of the paper can do any mischief. When the liquid has dissolved the precipitate, you filter the solution through a new filter, and thus separate the original filter from the solution produced by the precipitate. Another method of separating a precipitate from a filter is as follows:—You take the funnel which contains the filter and precipitate, still in a moist state, and fix it over the vessel which is to contain the solution produced by dissolving the precipitate. You then take the liquid which is to be employed as the solvent, and after making it boiling hot, if necessary, you pour it over the precipitate in the funnel. In passing through the filter it dissolves the precipitate, and separates it from the paper very neatly. In this manner peroxide of iron, which has been precipitated by ammonia, may be dissolved by hot muriatic acid.

Evaporation.—When an aqueous solution is exposed to heat, the water is converted into steam, and the solid matter remains behind. If you wish to obtain the solid contents of a

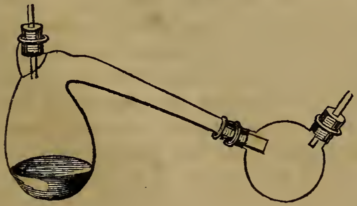
solution of considerable bulk, you must evaporate it in a Wedgewood's-ware capsule (p. 281). If the solution is of small bulk, you may employ the platinum capsule described at page 284. The capsule should be covered during the evaporation, partly to prevent the contamination of the product by dust, partly to prevent a loss of matter by ebullition or spirting. When the evaporation is slow, two glass rods may be laid across the capsule, and a double fold of blotting-paper be laid upon them. This paper should be changed as often as it becomes so soft, or so much corroded by acid vapours, as to be liable to fall into the solution.

When a solution is to be evaporated to dryness (p. 175), the operation must be performed with much care. When the mixture begins to get thick, the heat must be reduced, and the mass must be stirred with a glass rod uninterruptedly. If you do not proceed with this degree of care, the mixture will be unequally heated, a sputtering will take place, and a portion of the solid matter will be forcibly ejected from the capsule. You must break down all the hard lumps which appear, and mix the dry powder thoroughly with the moist part. If you cannot break down the lumps with a glass rod, you must employ a pestle. When the liquid has been driven away, the residue forms a fine powder.

If you wish to concentrate a large body of liquid, such as a pint of mineral water, you may boil it down in a Florence flask (p. 281).

Distillation.—If you expose an aqueous solution to evaporation in close vessels, you obtain the water and the fixed substances in a state of separation. If, for example, you put a solution of common salt into a Florence flask, then close the flask with a cork, and pass through the cork one end of a bent glass tube, of which the other end is connected in a similar manner to another flask; and if you boil the solution in the first flask while you cool the second flask by means of wet cloths applied externally, you will perceive that the water will gradually pass from the first flask into the second flask, so that, at the end of the operation, the first flask will contain all the salt and the second flask all the water. This is an example of distillation. It is by means of this operation that many liquids are obtained in a state of freedom from various solid non-volatile matters with which, under ordinary circumstances, they are contaminated. It is in this manner, for instance, that volatile acids are separated from salts, and water from earthy and saline matters.

The vessels most generally employed by chemists in the operation of distillation, are



retorts and receivers of glass. The retort is a pear-shaped vessel with a long neck bent on one side, some-

times provided with an additional opening called a tubulure, sometimes destitute thereof. A receiver is a globular vessel, provided either with one or two necks, according to the nature of the experiment for which it is to be used. In the figure, the tubulures, both of the retort and receiver, are represented as closed by corks through which pieces of glass tube are passed.

You ought to provide yourself with retorts varying in capacity from two ounces to a pint. The small ones should be plain. In selecting retorts or any other vessels intended to be exposed to fire, take care to pick out such as are very thin at the bottom, because such as are thick at the bottom generally break when put over the fire. The little glass tubes described at p. 283, serve both as retorts and receivers in a great number of cases, and he who can use the blowpipe, is able to modify their forms with the greatest facility.

The substances which are to be subjected to distillation, should be put into the retort with care. When it has a tubulure, they are to be inserted thereby. Solid bodies ought not to be dropped in so as to fall suddenly upon the bottom of the retort, otherwise they will make a hole and fall through. The retort ought to be held in an inclined position, and the small lumps should be allowed to slide in gently. If there is no tubulure, care should be taken, in placing the charge in the retort, not to soil the neck, otherwise the vapour which rises during the distillation will wash the neck of the retort and convey the impurities into the receiver. If the neck of

the retort is first made very clean and dry, solid substances may be passed in without soiling it. Liquids are then to be inserted by means of a funnel possessing a tube neck, sufficiently long to reach into the body of the retort and at the same time to project above its mouth. After the liquid has been poured into the retort, the funnel should be withdrawn in such a manner that the drop of liquid resting at the point of the funnel is kept from touching the interior of the neck of the retort. This is best managed by holding the retort in such a manner that the opening of its neck is rather lower than the part which joins the body of the retort.

The charge put into a retort ought seldom to occupy above one-third of its capacity. When a greater proportion of materials are inserted, the mass is liable to boil over.—During the distillation, the neck of the retort and the whole surface of the receiver, should be kept as cold as possible, by means of paper and cloths wetted with cold water, in order to facilitate the condensation of the vapours.

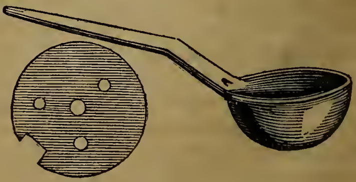
IGNITION.—It is often necessary to make a substance red-hot, either to free it from water or to decompose and char any organic substances which it may contain. Instances of this sort may be seen at pp. 275 and 5. Sometimes the ignition may be performed in a Hessian crucible (p. 6), or for want of that, in a clean tobacco-pipe (p. 48). But in

most cases the vessel in which a substance is exposed to ignition, is best when made of platinum; only, it is necessary to remember, that platinum vessels can never be employed when reguline metals, such as uncombined lead or copper are likely to be produced by the ignition (p. 6), or where free chlorine is likely to be disengaged during the experiment; as, for example, when muriatic acid comes into contact with the peroxides of manganese or of lead.

The simplest form of an instrument for ignition is a piece of platinum foil, as thick

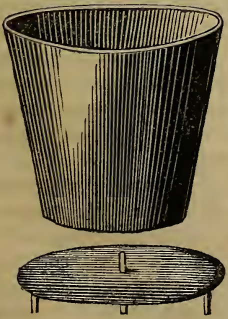
as stout writing paper and as large as the figure in the margin. The substance to be ignited is placed on one end of the foil, which is previously hollowed a little by the pressure of a finger, and is then exposed to the flame of a spirit-lamp or the action of the blowpipe.

When a substance is to be heated with fluxes, or when the quantity is somewhat considerable, it is convenient to ignite it in a little platinum spoon of the size of the



above figure. This spoon should be stuck into a tobacco-pipe handle, and should be provided with a cover. The latter ought to have three pegs below to keep it in its proper place on the spoon, and a centre peg on the upper side to serve for a handle. For certain experiments, a silver spoon of this form is convenient; but though such a spoon is much cheaper than one formed of platinum, it is too fusible and too easily acted upon by acids, to be generally useful. The cost of a platinum spoon of this description is eight or ten shillings.

An instrument more generally useful than the platinum spoon, but at the same time



more expensive, is the platinum crucible, which, with its platinum cover, is represented in the margin. The cost of a vessel of this size is about 2*l*. But those who wish to make experiments on qualitative analysis only, can have one made smaller and slighter for about 1*l*. I have indeed seen them without covers at ten shillings, but they were too slight to wear well. If any person wishes to practise analytical chemistry extensively, he cannot do without a platinum crucible as large as the above figure.

In many cases, where metallic crucibles are

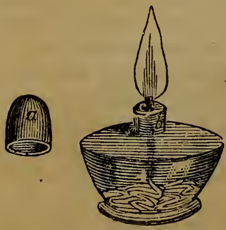
objectionable, it is proper to employ crucibles of porcelain or Wedgewood's-ware. These may be procured of various sizes; but those which are an inch or an inch and a half in diameter are most useful in qualitative analysis. They are furnished with covers like the platinum crucible. It is impossible to heat a substance so powerfully in a porcelain as in a platinum crucible, particularly over a lamp.

Substances of small bulk may be ignited in the platinum capsule (p. 284).

Fusion.—This operation is performed in the same vessels, in the same manner, and with the same precautions as "Ignition."

Application of Heat.—The method of applying heat differs according to the intensity of the heat required, to the bulk of the object to be heated, and the length of time during which the heat is to be sustained. It can be conveniently applied by means of a small spirit-lamp, a large spirit-lamp, an oil-lamp, a charcoal fire, or a blowpipe.

When you wish to apply a moderate heat, to evaporate a solution of small bulk, to heat the contents of a tube, or to ignite a small crucible, you make use of the small spirit-lamp. This consists of a short strong glass bottle, the neck of which contains a brass tube, holding a cotton wick. The bottle should be nearly full of spirits of wine of a

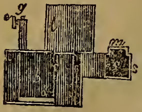


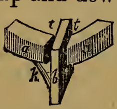
moderate strength. If highly rectified, it is too dear; if too much diluted, its flame is less powerful than it ought to be. Spirits of wine burns without smoke, so that a tube does not become soiled when heated in the flame of such a lamp. This is of considerable importance, for when a tube becomes coated with soot, as it does when you hold it over a candle, you cannot see what takes place within it during an operation. When you are going to heat the contents of a glass tube, you must approach the tube to the flame very gradually particularly if the bottom be thick. If you plunge it suddenly into the flame, the glass breaks and your preparation runs out.—The lamp should be furnished with a glass cap fitted to it by grinding, to prevent the evaporation of the spirit, when the lamp is not in use. When you want to extinguish the flame, you clap on this cap as an extinguisher.

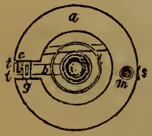
If you think a glass lamp, which may cost four or five shillings, to be too expensive, you may employ a small tin lamp, furnished with a tin cover, or you can construct a spirit lamp by putting a tin-plate tube or a short glass tube through the cork of a small broad bottle. You increase or diminish the power of the spirit-lamp, by making the wick thicker or thinner.

Experiments which require a great degree of heat, such as the ignition of refractory substances, require the assistance of the spirit-lamp with circular wick or double current of air. This is one of the most indispensable instruments of the analytical chemist, for there

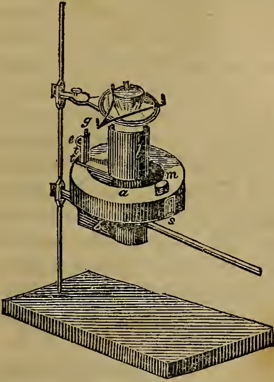
are many accurate experiments which cannot be performed without it.—The wick *c* passes below two cylinders which are connected below by a horizontal plate, and it can be raised or depressed by means of the toothed wheel *e* and the toothed bar *g*. The lower end of the latter is connected with a cross-bar *o*, upon the end of which a ring is fastened, on which ring the wick is stuck. The cross-bar and toothed-rod work up and down in the box *b*. This box does not form part of the spirit-holder *a a*, as it does in the common lamps, but is separated from it by the open spaces *t t*, or at any rate by a partition on each side. The spirit passes from *a a* into *b* through the pipe *k*, which forms the only communication between the spirit-holder and the box which holds the wick. The object of this contrivance is to prevent the explosion which frequently takes place when the common spirit-lamps are inflamed, and which is owing to the inflammation of the mixture of atmospheric air and vapour of alcohol which forms in the spirit-holder *a a*. At *m* is an opening by which the spirit is poured into the lamp. This is afterwards closed by a cork. A piece of glass is cemented in the front of the lamp, at *s*, to afford an opportunity of readily ascertaining how much spirit the spirit-holder *a* contains.







The lamp is provided with a copper chimney, *l*.



By raising or depressing the wick, the flame is increased or diminished. The air is brought to the spirit, externally by the side, and internally by the canal *i*. The wick must be cut quite level, and must never remain in a charred state. When a lamp is constructed in this manner and according to the following scale:—

———————————— one *foot*

it affords heat sufficient to fuse three-hundred-and-eighty grains of carbonate of soda in about fifteen minutes, supposing the salt to be contained in a platinum crucible of the weight of from three-hundred to three-hundred-and-eighty grains, and large enough to contain an equal weight of water. A lamp which is incapable of effecting the fusion of at least one-hundred-and-eighty grains of carbonate of soda, though useful in a great many experiments, is not powerful enough to be generally employed in the analysis of minerals. The experimental chemist ought to possess two lamps of this description; one for fusing, and another for other experiments. In the

latter case, the rods which support the lamp may be strong, but for the other lamp, the rods must be made as thin as possible, in order that they may not carry away too much of the heat.

As the wisdom of Parliament has made spirits of wine extremely expensive in England, and thereby prevented the industrious pursuit of analytical chemistry by English students, it happens that many who have more zeal than money attempt to perform imperfectly with oil-lamps what foreign chemists perform perfectly with spirit-lamps. Hence the origin of chemical oil-lamps in England, instruments which are every way inferior to spirit-lamps, but which are nevertheless come much into use here, in consequence, as I have observed above, of the wisdom of Parliament. It is this same wisdom of Parliament which prevents the glass-makers from making chemical vessels of green glass, which are infinitely superior to those of white glass, and which can be readily bought at any glass shop in France and Germany. But the wisdom of Parliament is exercised in England in putting students of practical chemistry to all sorts of practical inconveniences. This is one of the reasons why analytical chemistry makes so much more progress abroad than it does at home.

I wish most sincerely that it were possible to adulterate the wisdom of Parliament with a little common sense or elementary knowledge. In that case we poor English chemists might

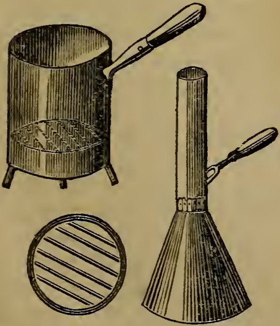
have some chance of keeping pace with our contemporaries in France and Germany. I have tried several times to find whether the wisdom of Parliament, as manifested in the prohibition of green glass retorts, did contain any common sense; but I never was able to to detect it.

When oil-lamps are employed, they should be filled with the clearest oil, and be provided with a copper chimney. Pyro-acetic spirit is coming into use as a fuel for chemical lamps. It is superior to oil. Its cost is nine shillings per gallon.

When you want to ignite a large crucible, or to evaporate a large bulk of liquid, it is best to employ a charcoal fire. The figure represents a furnace of iron-plate, constructed on the following scale :—

————————

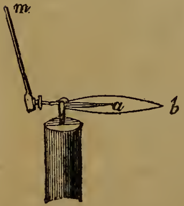
one *foot*.



A grate is fixed near the bottom, and the whole is supported on three short feet to permit air to enter below the grate. The inner side of the furnace may be lined with a coat of fire-clay half an inch thick, to keep the heat from escaping too freely. The funnel-shaped vessel is formed of iron plate, and

serves, when placed over the furnace, to make the fire burn fiercely. You should be provided with a round flat wire grating, which on being placed upon the furnace serves to support flasks and capsules which may be exposed to the fire. You should also possess several round flat pieces of iron plate as large as the top of the furnace, with holes in the middle to receive capsules and other vessels to be heated.

In many experiments, it is of great importance to be able to expose small substances to a very high temperature; in this case, it is necessary to employ the blowpipe, an instrument with which a current of air is blown into the flame of a lamp or candle. This gives one the power of producing in a moment, the most intense heat of a powerful furnace. You can easily perform with the help of this little instrument, the experiments which are necessary to determine the chemical nature of many different substances. You can produce any temperature up to a white heat. The blowpipe is a tube of brass,



about six inches long, and one fourth of an inch in diameter at one end. It tapers off to a fine point at the other end, where the orifice must be about the eightieth part of an inch in diameter. The point must be bent on one side, and the tube must be

furnished with a cylindrical reservoir to hold the water which air, blown from the mouth, deposits in the tube. In looking at the figure you are to suppose the point *m* to be in the mouth of the operator. In blowing through the tube, the current of air must be kept up without interruption. You breathe through the nose, and express the air from the mouth by means of the muscles of the cheeks. A little practice will enable you to keep up a continued blast.

You examine by means of the blowpipe, whether the substances are volatile or not, whether they become decomposed or not, what are the products of their decomposition, whether they are fusible or not, what phenomena they exhibit when fused with other substances, and how they act when heated so as to be oxidised or disoxidised. The disoxidation depends upon the part of the flame in which the substances are heated. In the blowpipe flame there are two sorts of combustion; in the interior by means of the air which is blown into the flame by the blowpipe; and at the exterior where the flame acts on the atmosphere. Between these two places there exists a mass of combustible gases which has a very high temperature. If you hold in these gases, that is to say in that part of the flame situated between *a* and *b*, any substance which contains oxygen, such as oxide of lead or oxide of copper, the oxygen of the oxides combines with the combustible gases, and the metal fuses and appears in the

reguline state. On the other hand, when any substances are held without the flame, and a little beyond the point *b*, they are strongly heated, and if oxidable, combine with the oxygen of the air, and produce oxides; a piece of tin, for example, if held in this situation, immediately produces a white oxide.

The fluxes with which metallic oxides are commonly fused are borax, carbonate of soda, and microcosmic salt or double phosphate of soda and ammonia. When borax is employed, the flux and assay are commonly heated together on a piece of platinum wire bent at one end into a ring. The subjoined figure exhibits the size and thickness of the wire.

When the other two fluxes are employed, the support is commonly a piece of well-burnt charcoal. The blowpipe experiment for the detection of chlorine (p. 59), requires the use of a copper wire of the annexed figure. The wire must be of the thinnest kind.

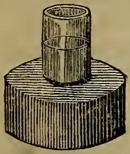
Brass wire may be used for the same experiment.

A common brass goldsmith's blowpipe, which costs sixpence, or a bent glass tube with a fine point, may be employed in the absence of a proper blowpipe.

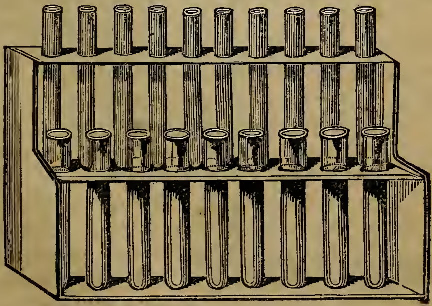
Platinum foil is a useful support for blowpipe experiments, and a pair of steel or brass forceps with narrow and thin platinum points, are indispensably necessary, when minerals and most other substances are to be

heated alone. But I refer you for detailed instructions respecting the use of the blowpipe to "*A Practical Treatise on the Use of the Blowpipe in Chemical and Mineral Analysis, by* JOHN GRIFFIN," and to "*The Art of Glass Blowing,*" which forms Vol. I. of the "*Polytechnic Library.*"

SUPPORTS.—The flask (p. 281) and the test tubes (p. 283) cannot stand alone; they must be retained in an upright position by some mechanical assistance. A single test-



tube may be supported by being placed in a glass with a flat bottom, or by means of a large perforated cork. But as in general, a great number of glass tubes are employed in testing a substance, it is proper to be provided with a small frame, holding about

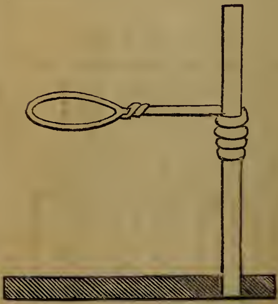


twenty of such glasses in two rows, the upper row containing tubes of a somewhat smaller size than those in the under row. The largest may be five inches long, and half an inch wide.

When the liquid contained in a glass tube is to be boiled over the lamp, you hold the tube near the top with the thumb and middle finger of the right-hand, and close the mouth of it with the fore-finger; or you may twist a

wire round the tube, and hold the end of the wire in your hand. It is prudent to adopt this plan when an explosion is to be apprehended.

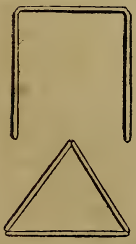
If you wish to support a capsule, a flask or a retort, over a lamp, you must employ a piece of apparatus, generally called a retort stand. This consists of a brass



or iron rod one third of an inch thick, and sixteen inches long, driven into the end of a piece of board, five inches wide, and nine inches long. It must be furnished with a horizontal arm, having a ring or a triangle at one end, and a coil or

worm at the other. This arm must be made of stout iron wire. You form the worm by fixing the large rod and the end of the wire into a vice, and then coiling the wire four or five times round the large rod. Such an arm moves loosely up and down the rod, but becomes fixed when a weight is placed on the ring. This ring can be made to support any sort of apparatus however small. You have only to lay upon it various sized triangles or trellis work of fine iron wire. When you want to heat a crucible, the thinner the wire by which it is supported, the more powerfully the heat is enabled to act upon it.

A simpler species of retort stand, but also a less substantial species, is constructed as follows:—You take three pieces of iron wire, one eighth of an inch thick, and about sixteen inches long, and bend each piece into the form of the adjoining upper figure. You then bind them together, by two and two, at the angles, with thin wire; by this means you produce a frame, the upper surface of which is a triangle, like the lower adjoining figure. The glass vessel to be heated is placed upon this triangle, and the spirit-lamp is placed below it, between the legs of the stand. This kind of support can be readily prepared and is both economical and portable.



II. *General Rules for Experimenting.*

It is difficult for those who are unaccustomed to the performance of analytical experiments, to determine upon what quantity of a substance it is best to operate. It is not advisable to take a very large quantity, even when the substance is present in abundance; but an analysis can often be very much facilitated, by submitting to experiment as many different portions of the substance for analysis as it is supposed to be composed of different constituents. This however is frequently impossible, when you have only a small quantity of the unknown substance. An analysis must never be undertaken with the entire quantity of a substance; but a portion of the substance must invariably be preserved for the proving and correcting of the first experiments.

A small portion of the unknown substance presented for analysis, must be first subjected to the following experiment, the object of which is to determine whether it consists of mineral substances only, or is a mixture of these with organic matters:—Employ a tube-matrass, similar to that depicted on page 283. Put into it a few grains of the substance to be tried, and heat it over the flame of a small spirit-lamp, holding the glass in a slightly inclined position. When organic substances are acted upon by heat, under these circumstances, they become charred, and assume a deep black colour. In general, also, they dis-

engage empyreumatic oil and empyreumatic water. When no organic matters are present, you determine, by this experiment, whether the substance contains water or other volatile matters. If water is present, it gathers upon the cold part of the interior of the tube. By passing a narrow strip of litmus paper into the tube so as to be wetted by the water, you observe whether the latter acts like an acid or an alcali. An alcaline reaction indicates the presence of ammonia.

It often happens that *inorganic* substances become black when heated, sometimes in consequence of the accidental presence of an extremely small proportion of an organic substance, and sometimes from other causes. But the blackness produced in such cases, is very different in appearance from that produced by charring an organic substance, as you may prove by igniting any organic substance in a glass tube, such as that which is here spoken of. But if you should at any time be in doubt whether the blackness produced by igniting a substance is attributable to the presence of organic substances or not, you may readily resolve the difficulty by performing the following operation. Heat a little nitrate of potash in a porcelain crucible; and throw a little of the unknown substance into the melted salt. If the unknown substance contains organic matters, it will produce a deflagration. This however is also the case with certain combustible inorganic substances, such as sulphur, the metallic sulphurets, and vari-

ous metals in a state of fine division. Nevertheless, when a substance becomes charred by heat and is made to deflagrate by melted nitre, it is almost sure to contain organic matters.

When a substance contains both organic and inorganic matters, and the nature of the latter is to be fully investigated, it is in general best to commence by totally destroying the organic matters. The reason of this is that the presence of organic matters has an extensive influence over the behaviour of inorganic matters towards re-agents, a fact which I have had frequent occasion to point out in the preceding pages. The best way to proceed is as follows:—Put a small quantity of the substance into a little platinum crucible (p. 303) and ignite it powerfully over the spirit-lamp with circular wick (p. 307). The crucible must be placed in an inclined position and the cover be laid on in such a manner as to cover only three-quarters of the top of the crucible. To promote the access of atmospheric air during the ignition, a small thin strip of untinned iron-plate must be placed in the open edge of the crucible. If the substance for analysis is suspected to contain metallic oxides which can be readily reduced to the metallic state by ignition with charcoal, the combustion of the organic substances must not be effected in a crucible of platinum, because the vessel, in such a case, would be totally destroyed. When therefore, lead, copper, or any easily-reducible metal is suspected to be present, the ignition of the

mass must be effected in a porcelain crucible. The operation is not so successful in this case; because, when a porcelain crucible is employed, the spirit-lamp is no longer capable of producing a degree of heat sufficiently strong to effect the entire combustion of the organic matters. But since the presence of many metals can be detected by liquid sulphuretted hydrogen or by hydrosulphuret of ammonia, and many earths and alcalies can be detected by other re-agents, even in spite of the presence of organic substances, it is often possible to effect an analysis by a systematic examination in the wet way, without any previous ignition of the substance. In such a case, however, you will do well to bear in mind the various cautions I have given in the preceding pages, in respect to the modifying power of organic substances as regards the action of re-agents.

Before proceeding to the analysis of a substance in the wet way, you must first ascertain by experiment, whether the substance is entirely, partially, or not at all capable of solution in water. The method of analysis differs in most cases, according to the degree of solubility of the substance; and it is in general more difficult with insoluble, than with soluble substances. To test the solubility of a substance, you put a few grains of it into a test-tube (p. 283), then pour distilled water upon it and shake it well. If any part remains undissolved, you hold the tube over the flame of a small spirit-lamp (p. 304) till the water

boils. If any part still remains in the solid state, you filter a little of the water, and carefully evaporate a few drops on a piece of platinum foil, over the flame of the small spirit-lamp. If it leaves any residue, the substance is partly soluble. If the liquor leaves no residue, the substance is entirely insoluble in water. It is easy to understand that none but distilled water must be employed in this experiment.

III. *Preparation of Chemical Tests.*

You must take particular care to obtain your re-agents in a state of the greatest purity: you cannot otherwise rely upon the indications of the phenomena they produce. Such as you prepare yourself, you must prepare with proper attention, and with pure materials; such as you purchase, you must never fail to examine by the processes detailed in the second part of this work.

Solutions of salts must be prepared by dissolving the solid substances in distilled water; and liquids of all kinds must be preserved in glass bottles provided with glass stoppers; the use of corks is inadmissible. The bottles and stoppers must fit well to each other, otherwise something may get into, or get out of the bottle, and in either case, spoil the re-agent. Thus, sulphuric acid may attract water from the atmosphere, or liquid ammonia may exhale ammoniacal gas.

You ought never to keep a large quantity of a test in solution, nor ever prepare a so-

lution which is liable to spontaneous decomposition, until the moment when you are going to employ it. In general, your saline solutions should be nearly concentrated, that is to say, the water should contain nearly as much of the salt as it is capable of dissolving. If at any time you require a dilute solution, for accurate neutralisation or other purpose, you mix a little of the concentrated solution with distilled water in a separate glass.

Your test-solutions must always be transparent and free from deposit. In preparing them, you put the salt and water into a glass, and stir them until the water leaves a portion of the salt undissolved. You then pour the solution through a paper filter, and receive it in a bottle which must be previously placed below the neck of the funnel.

Many crystalised salts can be partially freed from their impurities, by re-crystalisation. You dissolve the crystals in distilled water, filter the solution through paper, and evaporate it in a Wedgewood's-ware basin, placed over a lamp or furnace, until its surface exhibits a species of film. You then set the solution aside on a cushion to crystalise, and when it is cold, you separate the crystals from the mother-liquor, which, if small in quantity and not very valuable, is thrown away, but if of considerable bulk, is again evaporated and set aside to produce a second crop of crystals.

When you want to pour a drop or two of a liquid from a bottle, draw a wet line with the

stopper from the opening of the bottle to the edge of the rim; then hold the stopper against the end of the wet line, and gently incline the bottle. See the figure on page 287. If you attempt to pour a single drop from a bottle without this precaution, you may chance to pour out half a bottleful.

Distilled Water.—This is a very important article in chemical operations. When a solution is to be prepared or diluted with water, it is *distilled water* which must be employed. The use of common water is capable of introducing a variety of impurities into the solutions, the presence of which might sometimes lead to terrible fallacies. You may purchase distilled water at the druggists, but it is cheaper to prepare it yourself, unless you happen to be in very inconvenient circumstances. In the small way, proceed as follows:—Pour a pint of water into a retort; distil over a wine-glassful into a receiver; use that quantity to wash the receiver; then distil over two-thirds of what remains in the retort and preserve it for use. The retort can be heated over a lamp or charcoal fire; the receiver and the neck of the retort should be kept as cool as possible by the external application of cloth or paper wetted with cold water (p. 299).

Alcohol.—That which is to be employed as a chemical test ought to be very pure and highly rectified. That which is intended for fuel for lamps may be impure and somewhat weaker, but it must not contain too great a

quantity of water, otherwise it is less economical than strong alcohol, inasmuch as its combustion produces a very feeble degree of heat. You may burn pyro-acetic spirit for fuel, if you wish to save your money, and do not object to the smell of the spirit.

Turmeric Test Paper.—Boil a quarter of an ounce of pounded turmeric in half a teacupful of water for half an hour, and strain the decoction through muslin. Dip into this liquor a few pieces of thin yellow-wove post writing-paper, which will acquire a fine yellow colour. Dry the paper, cut it into slips two inches long and one-third of an inch wide, and preserve them in a box from light, atmospheric air, and acid vapour.

Litmus Test Paper.—This is prepared from a decoction of litmus, in the same manner as the turmeric test paper is prepared from a decoction of turmeric.

Mineral Acids.—The preparation of these re-agents is too difficult and dangerous to be undertaken by any but experienced chemists. I must counsel you therefore to buy them ready prepared, and always in the purest state you can meet with them. Ask for pure, or distilled acids. They are as follows:—

(a) *Sulphuric Acid.*

(b) *Muriatic Acid.*

(c) *Nitric Acid.*

Remember that these acids decompose all vegetable and animal substances. If you touch them with your fingers, you burn yourself. If you drop them upon your clothes,

you destroy the clothes. The bottles which contain them should be kept in a cool place, and nitric acid ought to be kept out of the light.

Concentrated sulphuric acid is employed to detect chlorine (p. 59) and many other substances. Diluted sulphuric acid is a test for barytes (p. 43), lead (p. 8), and many other bases.—Muriatic acid is a test for silver (p. 58), lead (p. 165) and other metals. It is also the acid which is commonly used to acidulate neutral or alcaline solutions, when it happens to be necessary to change their state. It serves also to detect carbonic acid (p. 172) and nitric acid (p. 53).—Nitric acid is often employed as a solvent in cases where the other acids would be objectionable (p. 164). It is sometimes employed to oxidise metals (p. 86), or to alter the state of oxidation of metallic solutions (p. 42).

Caustic Potash.—Buy it in the solid state. Dissolve it in water; allow the impurities to subside; and decant the clear solution into the bottle in which it is to be preserved. Grease the stopper with tallow to prevent its sticking in the bottle. When you wish to remove a little of the solution of potash out of the bottle, make use of the dropping tube described at page 288; never pour the solution from the mouth of the bottle. This solution acts powerfully upon animal and vegetable substances. It cannot be filtered through paper. It is a test for ammonia (p. 233), alumina (p. 48), lead (p. 8), and many other substances.

Liquid Ammonia.—Buy it. The stopper of the bottle it is put into, must fit well, and the bottle must be kept in a cool place. It is employed to render acid and neutral solutions alcaline, when a change of state is necessary (p. 25). It is a test for copper (p. 2), chloride of silver (p. 58), and many other compounds.

Carbonate of Potash.—The *sal tartari* of the apothecaries is carbonate of potash in a state of impurity. Buy crystalised bicarbonate of potash, ignite it in a platinum crucible over a large spirit-lamp; dissolve the residue in distilled water and filter the solution. It is a test for many earthy and metallic oxides.

Carbonate of Soda.—Buy purified carbonate of soda in crystals. Purify it by re-crystalisation. Dissolve it in distilled water. It is a test for many bases. The powdered crystals are used in experiments with the blowpipe, and in reducing processes (p. 6).

Carbonate of Ammonia.—Buy it in the solid state, dissolve it in distilled water and filter the solution. The bottle must have a stopper that fits well and should be kept in a cool place. It is a test for many earths and metals.

Preparation of Gases.—The gases which are principally employed in analytical chemistry, are sulphuretted hydrogen gas, chlorine gas, hydrogen gas and carbonic acid gas. Other gases are occasionally made use of in particular operations; but they are not

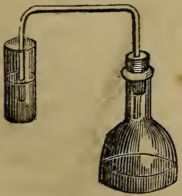
required in the analyses which have been described in the preceding pages.

In preparing these gases, you employ a Florence flask (p. 281), or a bottle like that described at page 282. You put into the bottle the materials whose re-action is to produce the gas, and then close the neck of the bottle with a cork provided with a bent glass conducting-tube. This should have the form of a bracket ⊓ with two long descending legs. The tube ought to be one-third of an inch in diameter, and have a bore one-sixth of an inch in diameter. The end of one of its legs should fit tight into a hole made through the cork with a hot wire and a rat's-tail file, and the other end should be left at liberty. If you fix the cork into the neck of the bottle, and then apply your mouth to the open end of the tube and *suck* strongly, you will ascertain whether or not the joinings of the apparatus are air-tight, which they must be, made to be. You will of course make this trial when the bottle is empty, and not while a gas is being generated within it. The materials put into a bottle to produce a gas, must never exceed in bulk the third or fourth part of the capacity of the bottle, otherwise they are apt to boil over when the action comes to be powerful and the disengagement of gas rapid.

You must take care not to respire an atmosphere contaminated by deleterious gases. Experiments with gases ought not to be made in a close apartment; but either under a large

chimney or in the open air. Sulphuretted hydrogen gas is a particularly powerful poison, and it is fortunate that its noisome odour gives timely notice of its presence. Chlorine gas is exceedingly disagreeable to breathe, but is not so injurious as sulphuretted hydrogen gas.

Solutions of Gases.—When gases are prepared for analytical experiments, they are generally made to act upon liquids. In this case, the extreme end of the conducting-tube is made to dip into the liquid which is to be exposed to the action of the gas. In proportion as the gas is forced from the flask in which it is generated, it passes into the liquid at the end of the tube, and is there absorbed.



The liquid to be acted on by the gas, may be contained either in a cylindrical solution-jar (p. 282), or in a bottle provided with a glass stopper. The latter is often made use of with advantage when the liquid is to be completely saturated with the gas. When the gas has been passed for some time into the liquid, you withdraw the bottle from the tube, put in the stopper and shake the bottle. If, upon withdrawing the stopper, there is a rush of air into the bottle, the liquid is still unsaturated; if, on the contrary, there is no rush of air, and the bottle smells strongly of the gas, then the liquid is near the point of saturation.

Experiments of this description are liable to a variety of accidents, unless they are performed with a suitable degree of care. I shall mention these accidents and the means of preventing them.—1. If the mixture which disengages the gas is thick and the effervescence so powerful as to force a portion of the mixture into the tube, the bottle may burst in consequence of the inability of the gas to escape through the obstructed tube. To prevent this, you must, as before directed, put but a small quantity of the mixture into the bottle, and you must keep the action moderate and regular by a suitable application of heat.—2. If the mixture boils over into the liquid which is exposed to the action of the gas, the whole operation is spoiled. To prevent this, you must take notice when the mixture rises up in the bottle, and either remove the lamp from below the bottle, or the liquid from the mouth of the conducting-tube.—3. If the disengagement of gas from the mixture happens to slacken in consequence of the application of too low a degree of heat or of some other cause, a vacuum is produced in the bottle, and the liquid which is exposed to the gas is forced through the gas-tube into the bottle. In this case, the operation is ruined, the liquid lost, and very often the bottle broken. To prevent this, you must keep the tube dipped but a little way into the liquid, so that, when you observe the liquid begin to mount into the tube, you have only to lower the vessel a little so as to bring

the liquid below the mouth of the tube, to avoid the above effect. You must also take care to heat the gas-bottle with a steady and regular fire. Remember, that an operation of this sort must never be neglected. You must watch the progress of a distillation as a cat watches a mouse. Your eyes must never be off the vessels, and your hands must never be occupied with any other business than that belonging to the process. A single moment of inattention may ruin the result of many days' labour.

The eagerness with which the solution and the mixture in the gas-bottle encroach upon each other's domain are such, that it is advisable, in all experiments of importance, to place an intermediate vessel between the other two. This may be a Woulfe's bottle, with two necks, or a receiver, similar to the one represented at page 299. The three bottles are connected together by corks and glass tubes. In this case, the solution is less liable to be spoiled, and the gas bottle less liable to be broken, than when the solution and the bottle are connected only by a single tube.

It is sometimes necessary during a distillation to give a fresh supply of acid to the mixture in the gas bottle. To be enabled to do this, without interrupting the process, it is proper to provide the neck of the bottle with a cork containing two holes, instead of one. You fix into one of these holes the tube which is to convey the gas, and into the other a tube with a small funnel at its upper end,

and with a neck so long that it dips into the liquid contained in the gas-bottle. It is by means of this funnel and tube that you are to introduce the acid at all times when it is required.

When the gas-bottle is to be exposed to heat, it must be held over the lamp by one of the supports described at pages 314 and 315.

Chlorine Gas.—Mix concentrated muriatic acid, contained in a flask or gas-bottle, with half its weight of finely-pulverised peroxide of manganese; shake the mixture till it forms a thick paste; then apply a gentle heat. The gas is disengaged pretty rapidly.

Liquid Chlorine.—Receive chlorine gas in cold water, in the manner described in the article on solutions of gases (p. 327).

Sulphuretted Hydrogen Gas.—Mix pulverised gray sulphuret of antimony with four or five times its weight of strong muriatic acid. Proceed afterwards as directed above. It is necessary to apply a slight heat to the bottle which contains the mixture.

Liquid Sulphuretted Hydrogen.—Pass sulphuretted hydrogen gas into water, until the water is completely saturated. This test only acts well when it is newly prepared, because the gas rapidly escapes. The bottle which contains it ought always to be retained in an inverted position.

Hydrosulphuret of Ammonia.—Pass a current of sulphuretted hydrogen gas into liquid ammonia, until the ammonia is saturated with the gas. The bottle which con-

tains the liquid ammonia should have a very narrow mouth, because the contact of atmospheric air is to be avoided as much as possible.

Hydrogen Gas.—Put iron nails, or wire, into a mixture of sulphuric acid and water. The gas is disengaged without the application of heat. If you wish to dry the gas, make it pass through a tube containing lumps of chloride of calcium. This tube may be connected with the gas tube by means of a cork. The gas can be conveyed from the other end of the tube containing the chloride of calcium, by a third tube. Hydrogen gas is employed in reducing oxides and sulphurets to the metallic state (p. 15).

Carbonic Acid Gas.—Pour diluted muriatic acid over lumps of marble or chalk. The gas is immediately disengaged. It is unnecessary to apply heat. This test affords precipitates with solutions which contain substances capable of producing insoluble carbonates.

Red Prussiate of Potash.—Pass a current of chlorine gas into a solution of yellow prussiate of potash, until the solution, from being greenish, becomes red (which is best to be seen by candle light), or until it ceases to give a blue precipitate with a solution of perchloride of iron. If the solution is intended for *beer-test* (see page 41), it is not necessary to add so much chlorine as is required to decompose the whole of the yellow prussiate of potash, because the presence of a

portion of the latter is an advantage. But if you wish to obtain the red salt in a state of purity, you must proceed as I have stated It is best to put twenty or thirty drops of a solution of perchloride of iron round the edge of a plate, and to provide a number of glass rods. Every time you shake the bottle after removing it from the gas tube (p. 327), you should dip a glass rod into the solution, and touch one of the drops of perchloride of iron. When the solution ceases to turn the drops blue-green, it contains as much chlorine as it ought to contain. The solution must not retain a strong smell of chlorine, otherwise it contains too much of that element. This is a misfortune, because an excess of chlorine converts the red prussiate of potash into chloride of potassium and prussian blue. If, therefore, you should accidentally give the solution too great a quantity of chlorine, you must neutralise it by adding a fresh solution of yellow prussiate of potash.

Filter the resulting solution of red prussiate of potash, pour it into a confectioner's glass, and evaporate it at a low temperature. You will then observe the formation of needle-shaped crystals of a red colour. Remove these crystals from the solution, dissolve them in water, filter the solution, and slowly evaporate it in a confectioner's glass. It will afford crystals, which must be again dissolved, filtered, evaporated and crystalised. Finally, if you operate on a considerable quantity of the salt, you will obtain large and beautiful

crystals of a magnificent red colour. But the purification and crystalisation of this salt are most troublesome and tedious operations.

They are, however, quite unnecessary to be performed with a solution which is intended for a beer-test. You may content yourself in this case, with passing into the solution merely that quantity of chlorine which is necessary to give the solution a reddish colour. The beer-test is then prepared.

Saline Solutions.—Buy the fifteen following salts in the state of purified crystals. Dissolve the crystals in distilled water, filter the solutions, and re-crystalise the salts (p. 321). Dissolve the purified crystals in water, filter the solutions, and preserve them for tests.

1. *Nitrate of Silver.* The solution must be preserved in a dark place, because light decomposes it. This solution stains your fingers black, and forms indelible black stains on linen. It is very poisonous. It is a test for chlorine or muriatic acid (p. 58). But you must bear in mind that it produces precipitates with sulphuric acid, bromic acid, phosphoric acid, boracic acid, arsenic acid, arsenious acid, bromine, and iodine.

2. *Chloride of Barium.* (Muriate of barytes).

3. *Nitrate of Barytes.*

4. *Acetate of Barytes.*

These three solutions are tests for sulphuric acid (p. 53). The acetate is also employed to convert the sulphates of earths and

alcalies into acetates or carbonates. The solution of the sulphates is precipitated by the solution of the acetate of barytes, and the resulting solution is filtered and evaporated.

5. *Oxalic Acid.*

6. *Superoxalate of Potash.*

7. *Oxalate of Ammonia.*

These three solutions are tests for lime (p. 45).

8. *Sulphate of Potash.*

9. *Sulphate of Soda.*

These two solutions are tests for barytes (p. 43), and lead (p. 8). They also precipitate solutions of lime, but not so readily as those of barytes and lead.

10. *Phosphate of Soda.* This solution is a test for magnesia (p. 259).

11. *Yellow Prussiate of Potash.* This solution is a test for copper (p. 71), peroxide of iron (p. 39), tin (p. 71), and many other metals.

12. *Chromate of Potash.* This solution is a test for lead (p. 13), and many other metals.

13. *Nitrate of Potash.* The solid crystals are employed as a test for carbonaceous substances (p. 317).

14. *Iodide of Potassium.* The solution is a test for starch (p. 153), for distinguishing calomel from corrosive sublimate (p. 30), and for many metals.

15. *Sulphate of Copper.* The solution is a test for arsenic (p. 25).

Lime-water. — Mix newly-burnt pure lime with water; shake the mixture fre-

quently, and afterwards filter it. You must protect it carefully from the air, otherwise the lime absorbs carbonic acid and the solution becomes contaminated by a precipitate. It is a test for carbonic acid (p. 261).

If you cannot procure pure burnt-lime, take a piece of crystalised calc-spar or white marble, and ignite it strongly in a platinum crucible, placed within an earthen crucible, in a charcoal fire. The calc-spar is thus converted into caustic lime.

Indigo Solution.—Put a very small quantity of powdered indigo into a bottle, add a few drops of the most concentrated oil of vitriol, close the bottle and shake it frequently. Next day dilute the mixture with a large quantity of water, filter it and preserve the clear blue solution. It is a test for nitric acid (p. 57), and for bleaching liquors (p. 119).

Sulphate of Strontian.—Add an excess of sulphuric acid to a solution of nitrate of strontian or of chloride of strontian; filter the solution, and wash the precipitate until the washings do not change the colour of litmus. Boil the edulcorated precipitate in distilled water, allow it to cool, filter the solution and preserve it. A test to distinguish barytes from strontian (p. 44).

Sulphate of Lime.—Prepared in the same manner as sulphate of strontian, chloride of calcium being substituted for chloride of strontian. A test to detect oxalic acid and to distinguish lime from strontian or barytes (p. 43).

Sulphate of Silver.—Add an excess of sulphuric acid to a solution of nitrate of silver; then proceed as in the preparation of sulphate of strontian. A test for muriatic acid (p. 60).

Nitrate of Cobalt.—Dissolve metallic cobalt, oxide of cobalt, or carbonate of cobalt, in nitric acid, and concentrate the solution by evaporation. It is a test for magnesia and alumina (pages 50 and 174.)

Protochloride of Tin.—Dissolve pure tin in warm muriatic acid, evaporate the solution and set it aside to crystalise. Dissolve the crystals in distilled water, and add a little muriatic acid to render the solution clear. You must prepare the solution every time you want it, as it will not keep good. It is a test for mercury (p. 29).

Chloride of Platinum.—Mix two parts of concentrated muriatic acid with one part of concentrated nitric acid; dissolve a small piece of platinum in the mixture, and evaporate the solution to dryness in a capsule of Wedgewood's-ware. Dissolve the dry chloride in spirits of wine. It is a test for potash (p. 50) and salts of ammonia, with solutions of both of which substances it gives a yellow precipitate.

Chloride of Gold.—It is prepared in the same manner as the chloride of platinum. It is a test for tin (p. 76).

Perchloride of Iron.—Boil strong muriatic acid with an excess of red oxide of iron; filter the solution. A test to dis-

tinguish red prussiate of potash from yellow prussiate of potash. It gives a blue precipitate with the yellow salt, but none with the red salt.

Tincture of Galls.—Digest a bruised nut-gall in a cold mixture of water and alcohol; after some hours filter the solution. It is a test for iron in mineral waters (p. 258).

Tartaric Acid.—Buy it in crystals, and preserve it in that state. When you want a solution, dissolve a few of the crystals in water. The solution is liable to spontaneous decomposition. It is a test for potash (p. 50).

Tartrate of Lime.—Mix a solution of chloride of calcium with a solution of supertartrate of potash; filter the solution, and wash the precipitated tartrate of lime with the edulcorator (p. 295). It is a test for arsenic (p. 24).

Muriate of Ammonia.—Buy purified sal-ammoniac; dissolve it in water and filter the solution. It is employed to hinder the precipitation of magnesia by ammonia (p. 174).

Blank Iron. A test for copper. Use a clean knife-blade.—Gold Leaf. A test for nitric acid. Buy it of bookbinders, gilders, or gold-beaters.—Copper Filings. A test for nitric acid. File a copper wire with a steel file.—Starch. A test for iodine. Boil a little common starch in water in a glass tube.—Iodine dissolved in alcohol. A test for starch. Heat a scale of iodine in a drop of alcohol in a glass tube. Pour the liquid which is to be tested into the tube.—Copper-plate. A test for mercury.

Slips of polished copper can be had of any coppersmith.

Prometheans.—When engaged in the performance of chemical experiments, you will often find it very convenient to be able to procure an instantaneous light. You will sometimes want to light a spirit-lamp in order to heat a tube, or a small oil-lamp or candle to be used with the blowpipe. In all such cases, it is good to have the power of procuring a light without loss of time.

One of the best contrivances for procuring a light when no fire is at hand, is a little article which has recently become an article of commerce in London, under the name of the *Promethean*. It consists of a roll of paper having a solid red substance enclosed at one end. When you wish to procure a light, you lay the red end of the paper on a table, and give it a knock with a key or other hard body. Thereupon the paper immediately inflames.

If you soak one of the prometheans in water, and then spread it open, you will find its construction to be extremely simple. The paper is a parellelogram of two inches by one in size, with a triangle cut off at one corner to remove a projection which would otherwise be situate where the red substance is put. This red substance is a mixture of chlorate of potash and sugar, coloured by vermilion, and made into a mass with gum. If you shake it in water, the vermilion precipitates, while the other substances dissolve.

When you come to shake the red substance in water, you find that it is not homogeneous; but that, though itself of no greater bulk than a barley-corn, it contains a vessel of glass of the size and shape of a canary seed, excepting that it is round instead of being flat. This little vessel is closed at both ends, and is easily seen to contain a liquid. If you crush it and put the fragments into water, you will find, by applying a solution of chloride of barium, that the liquid which is contained in it is no other than sulphuric acid.

This is the whole secret of the promethean! When you knock the end of it, you make the imprisoned sulphuric acid come into contact with the mixture of sugar and chlorate of potash; the mixture then inflames, and the inflammation is communicated to the paper.

Directions for making Prometheans.—Take equal parts of finely-pounded chlorate of potash and loaf-sugar; add a small quantity of pulverised vermilion, and mix the whole intimately together; first in the dry state, and afterwards with a solution of gum arabic, by which you make it into a dough.

Caution. The salts must be well-pounded before they are mixed together, and after being mixed must be treated very gently. A mixture of chlorate of potash with sugar is liable to explode if struck violently, or exposed to very rude handling. You should mix only a small quantity of the compound at once.

To make the glass-beads, hold a thin glass tube over the flame of a lamp, and when the

glass is soft, draw it out till it is about as thick as a knitting-needle, or rather until it forms a series of little ovals. Break these asunder so as to leave each oval one-third of an inch long. Close one end by holding it in the flame, then warm the oval by holding it in a pair of pincers over the flame, and while it is hot, dip the open end into sulphuric acid, a portion of which will then rise up into the oval. The open point can finally be closed by being held in the flame, or by having the blowpipe flame directed upon it. The most difficult part of the operation is the closing of the last point, because the heat applied for that purpose is very apt, if clumsily directed, to expel the sulphuric acid from the little vessel.

The paste and the glass beads being provided, you take a slip of paper of the form above described; you spread a solution of gum arabic across that end of the paper where the corner is cut off, and then roll it up into a cylinder, leaving a hollow at the gummed end. You then take a small piece of the red mixture, put one of the glass beads in the middle of it, and force the whole into the open end of the paper roll, in which place you fix it by a gentle squeeze with the fingers. The promethean is then finished. However, it requires to be well dried before it can be made to inflame.

WILLIAM HENRY COX,
55, GREAT QUEEN STREET, LINCOLN'S INN FIELDS, LONDON.